INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

VOL. XI NO. 9 SEPTEMBER, 1961 RUPEES TWO

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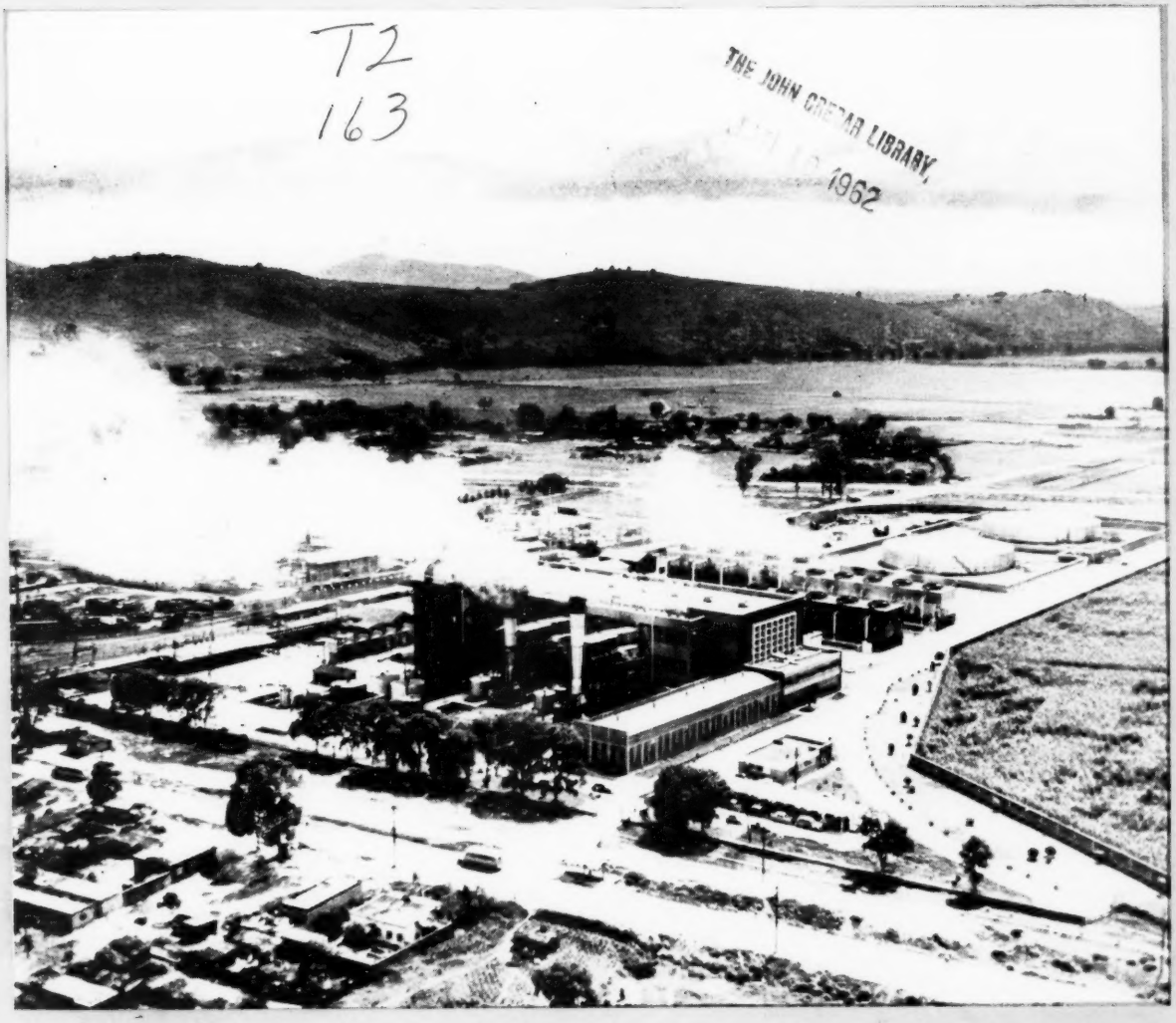

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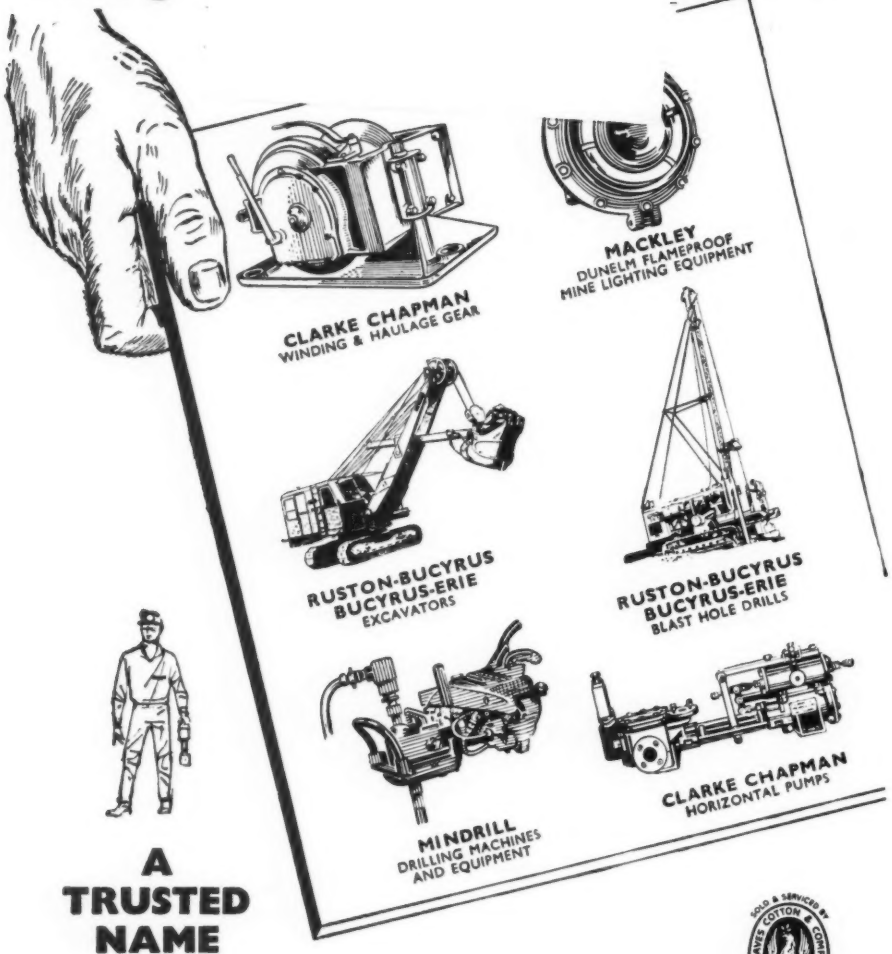

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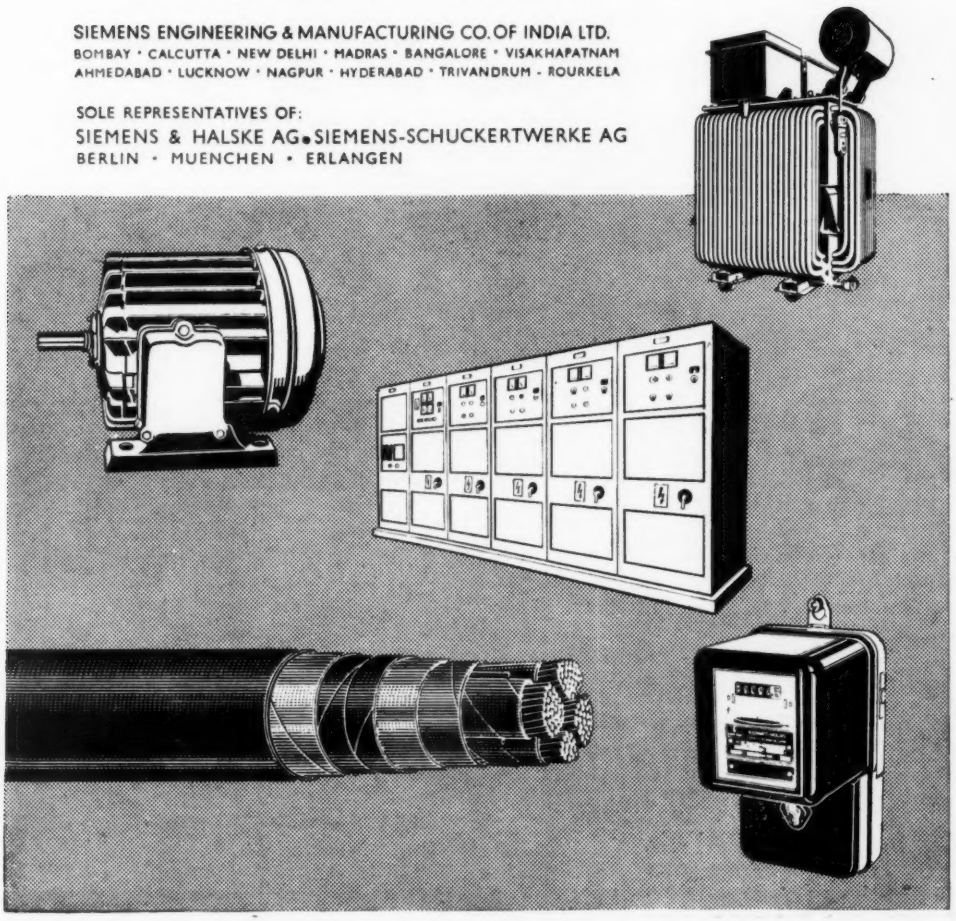

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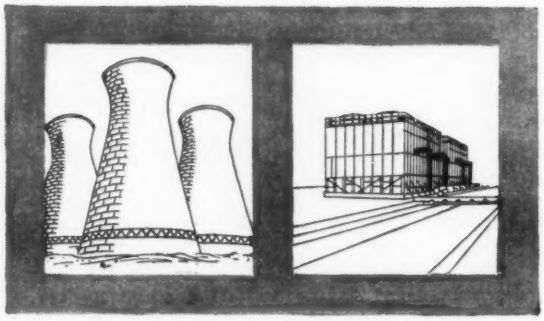

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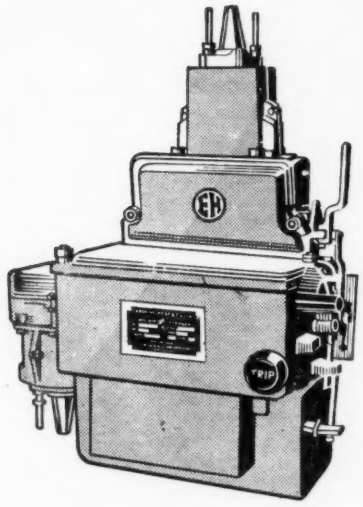

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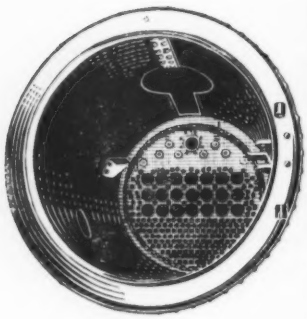

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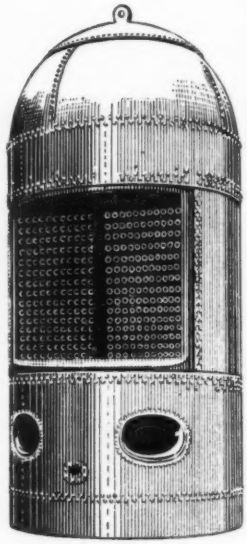

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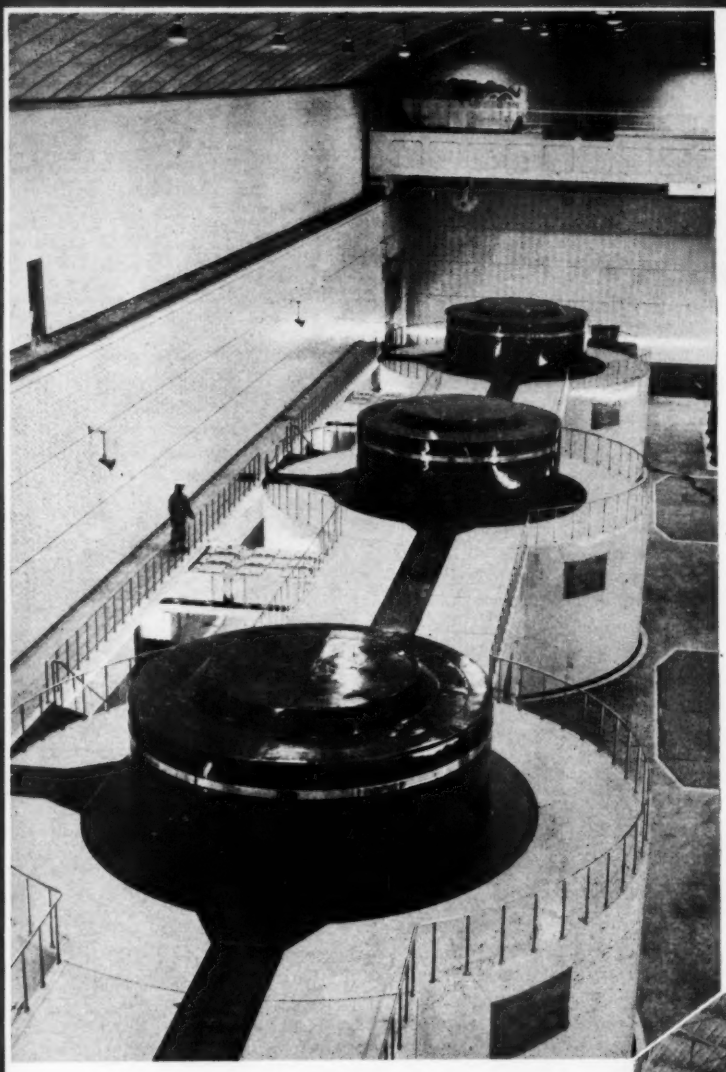

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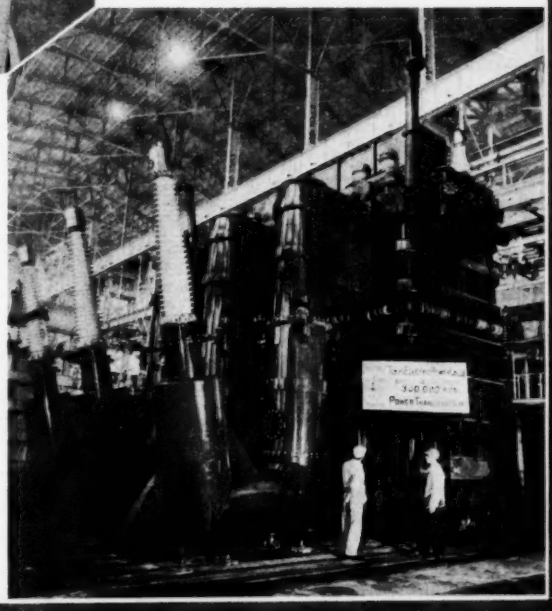

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Varying Conditions

Wherever new steam-raising plant is to be installed, either for generating power or in industry, it is essential that skilled investigation and analysis be carried out to ensure that the plant is *tailor-made* to give optimum performance under varying *local* conditions and requirements.

Fuel

Having established the purpose for which the steam power created will be required, it is necessary for the design engineer to identify the type of fuel to be used, either oil, gas or coal. Coal is by far the most widely used fuel, but its thermal content varies and it is therefore necessary to make an analysis to establish the percentage of principal heat-producing elements present. The thermal content of fuel has an important bearing on the designing of the kind of plant to be installed. Generally low-grade coal is used with anything up to 50% ash content. It should be remembered that steam must be raised as economically as possible.

Waste fuel

Particular attention has to be given to industries that wish to use waste material as fuel. For instance, the sugar industry absorbs vast quantities of waste material in the form of bagasse for fuel; again in the pulp and paper industry it is now the practice to combine the processes of chemical recovery and steam raising by burning the 'black liquor' from the digestors in a special type of boiler unit. Of course, these industries cannot keep their steam-raising plant functioning entirely on waste materials. So, in their designing and planning, the technicians and design engineers must allow for varying fuels to be used and at the same time achieve optimum performance.

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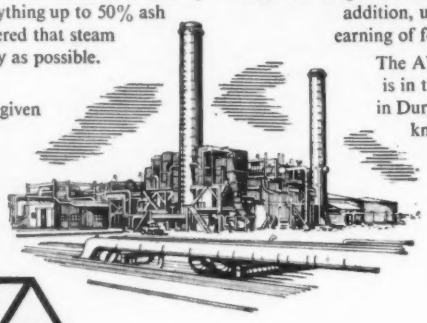
The new and powerful industrial group of ACC-Vickers-Babcock Ltd., with its vast resources of technical knowledge and the rich, wide experience of its partners, will undoubtedly prove a powerful ally in achieving the high target set by the government for the installation of boiler and thermal power plant during the third Five-Year Plan. AVB will be able to draw on the finest engineering minds to study, design and draw up plans that will *tailor-make* not only vital steam-raising plant but also heavy mining and cement-making machinery which will help meet the exigencies of industrial expansion and, in addition, ultimately contribute towards the earning of foreign exchange through export.

The AVB industrial plant at Durgapur is in the final stages of erection. Here, in Durgapur, all the advanced technical knowledge of AVB will be utilised to the fullest extent to ensure that each project is designed for the finest possible performance.



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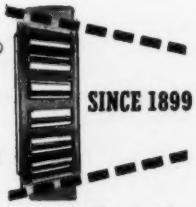

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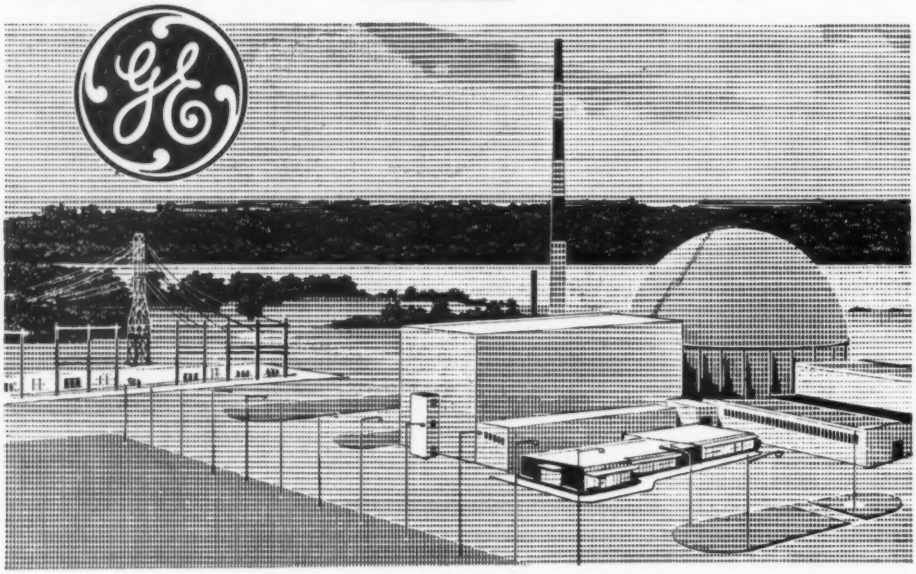

Commonwealth Edison Company's Dresden Nuclear Power Station near Chicago, Illinois, reached full power operation for the first time on June 29, 1960.

This General Electric designed and built power station is the LARGEST Atomic Power Plant in the U.S. Upon attainment of full-power operation, it sent 180,000 Kilowatts of electricity over transmission lines into Chicago and Northern Illinois.

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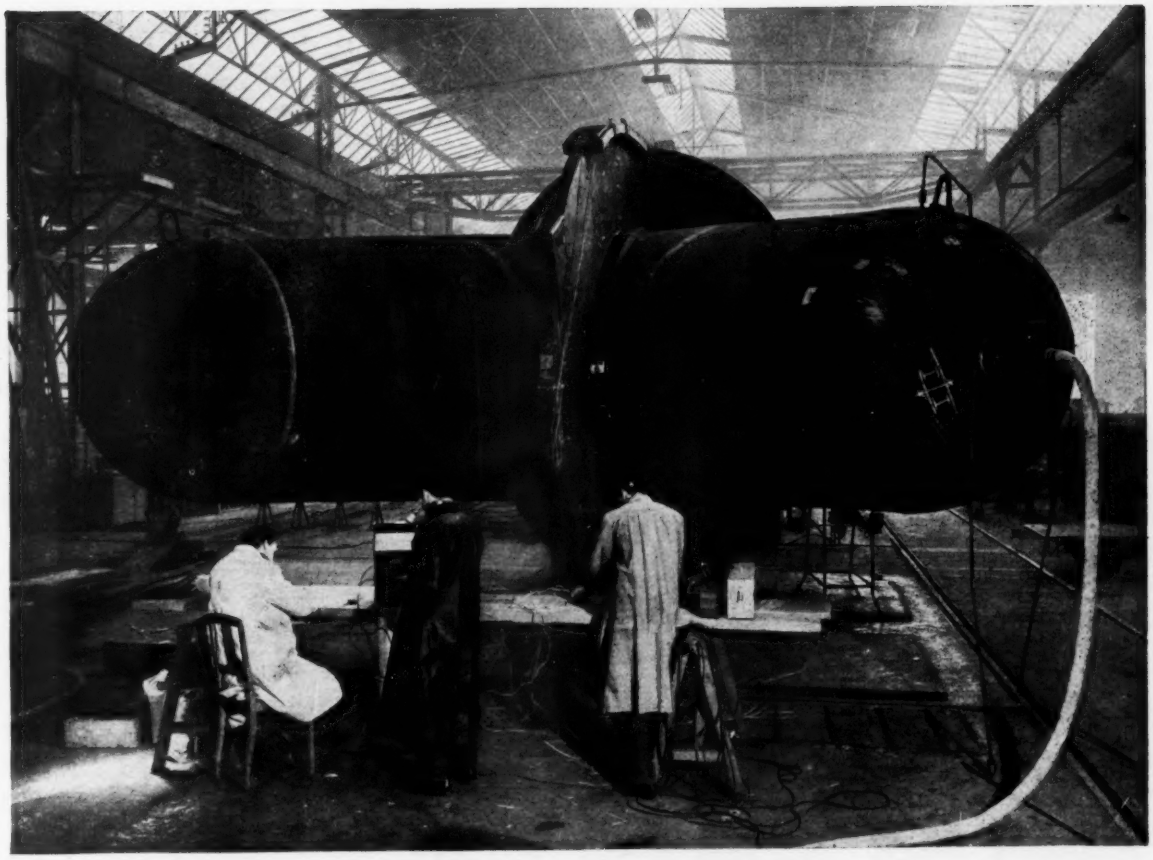

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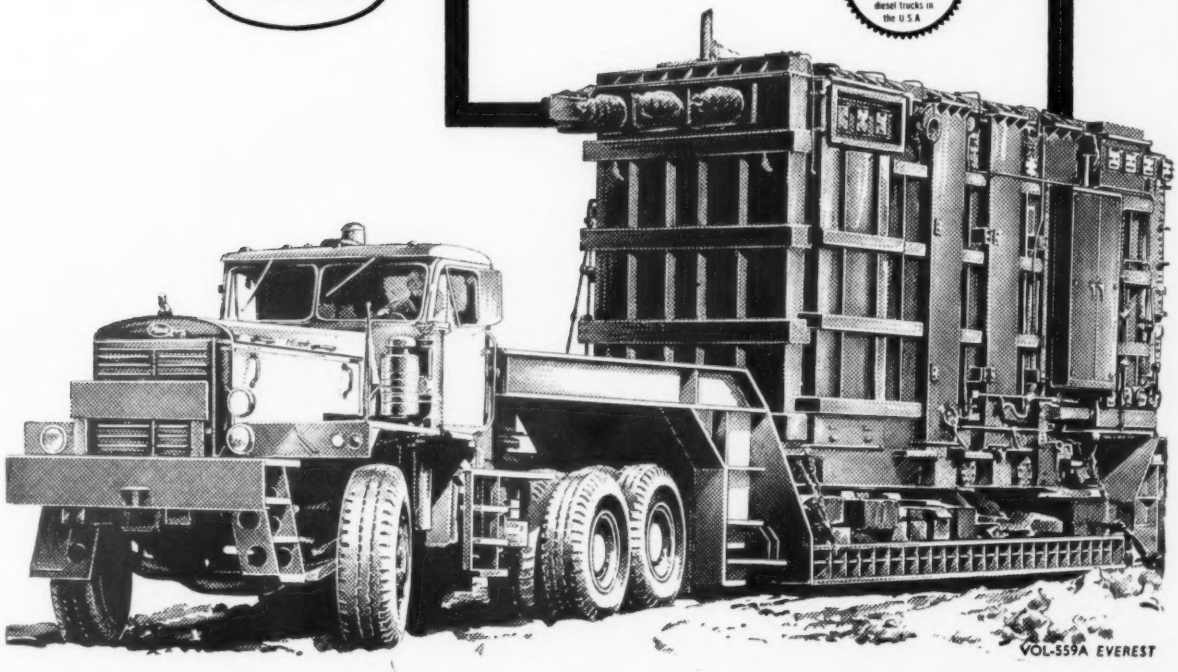
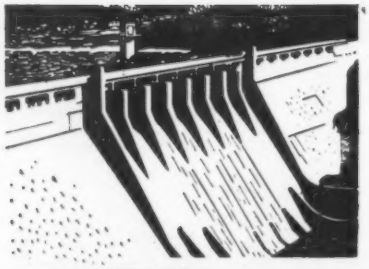
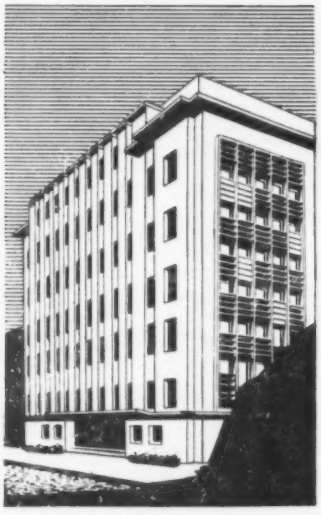
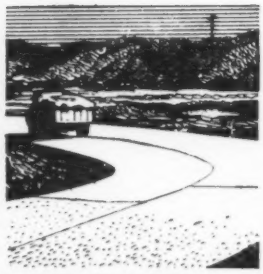
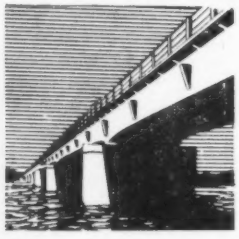


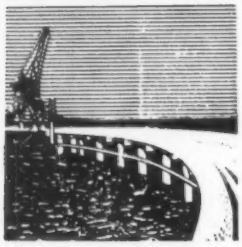
Portland Blast Furnace Slag Cement











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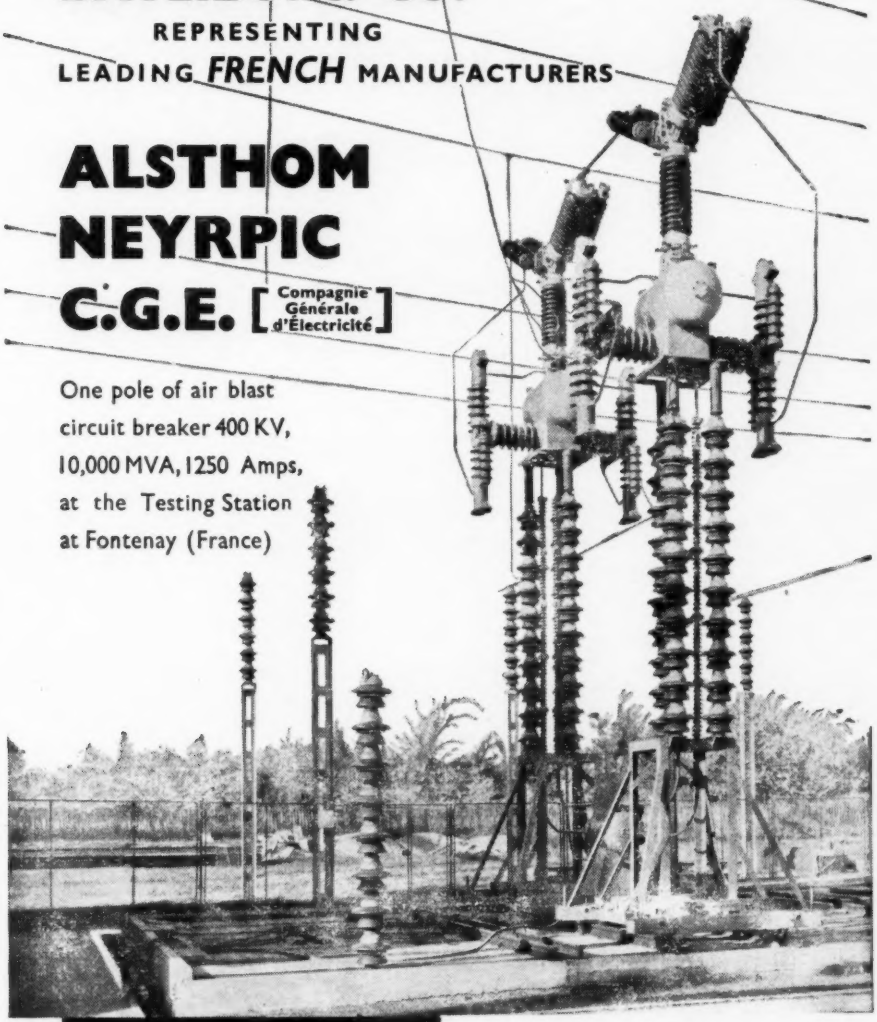

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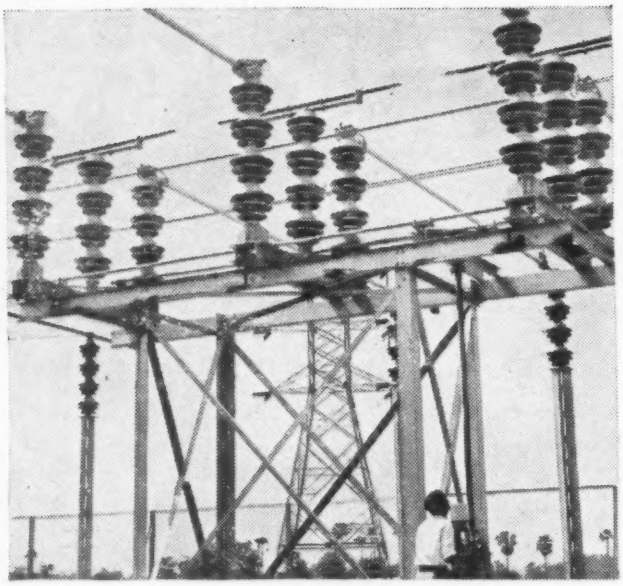

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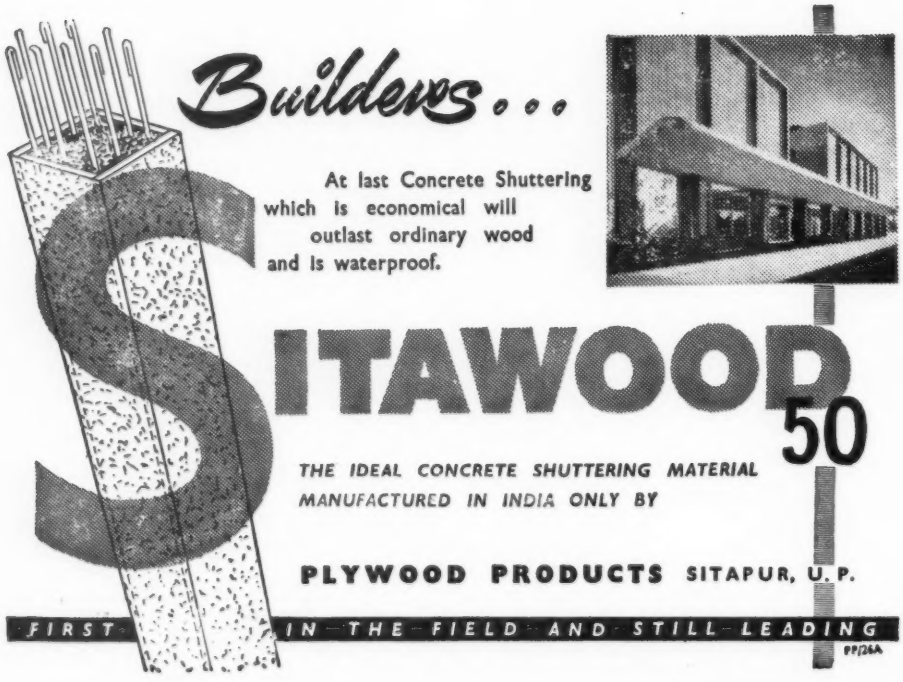
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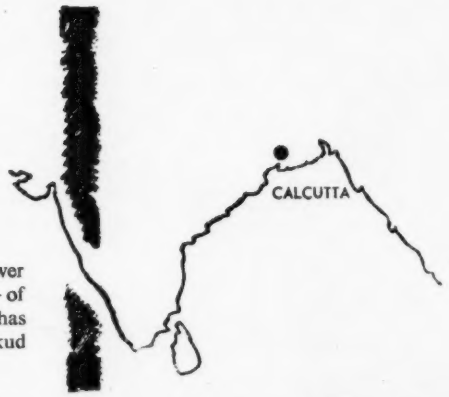
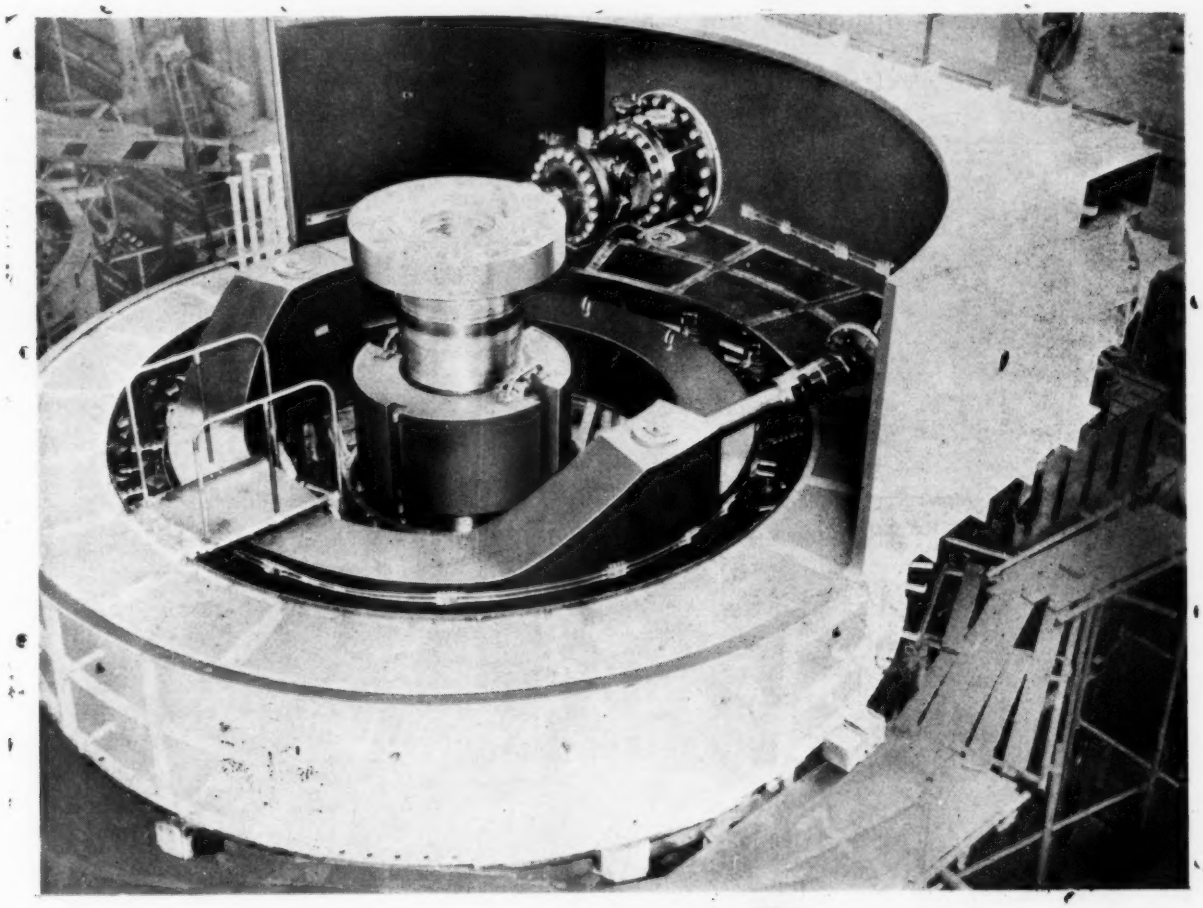


Closely following the official opening of the Bhakra Power Station — equipped with five Francis turbines by Hitachi — of the Punjab State Government, Hitachi, Ltd. of Japan has completed a 52,000 HP Kaplan turbine for India's Hirakud No. 1 Power Station.



Transportation from Japan to India and installation of the new Hitachi turbine — the Hirakud Power Station is 300 miles west of Calcutta — is on scheduie.

Hitachi's engineers designed this giant Kaplan turbine for a maximum head of 119 feet, discharge of 5,900 cusecs and a speed of 150 rpm, and its special construction is capable of resisting massive water pressure.

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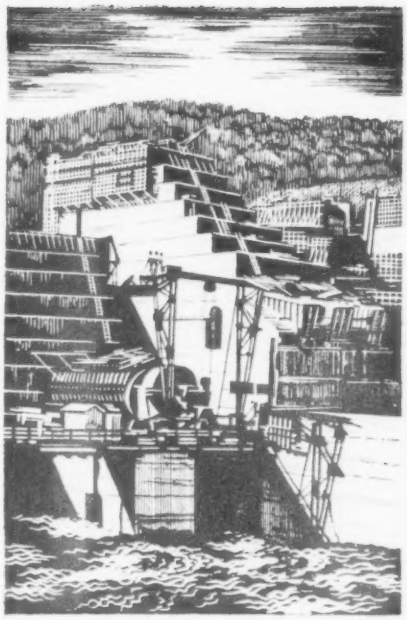

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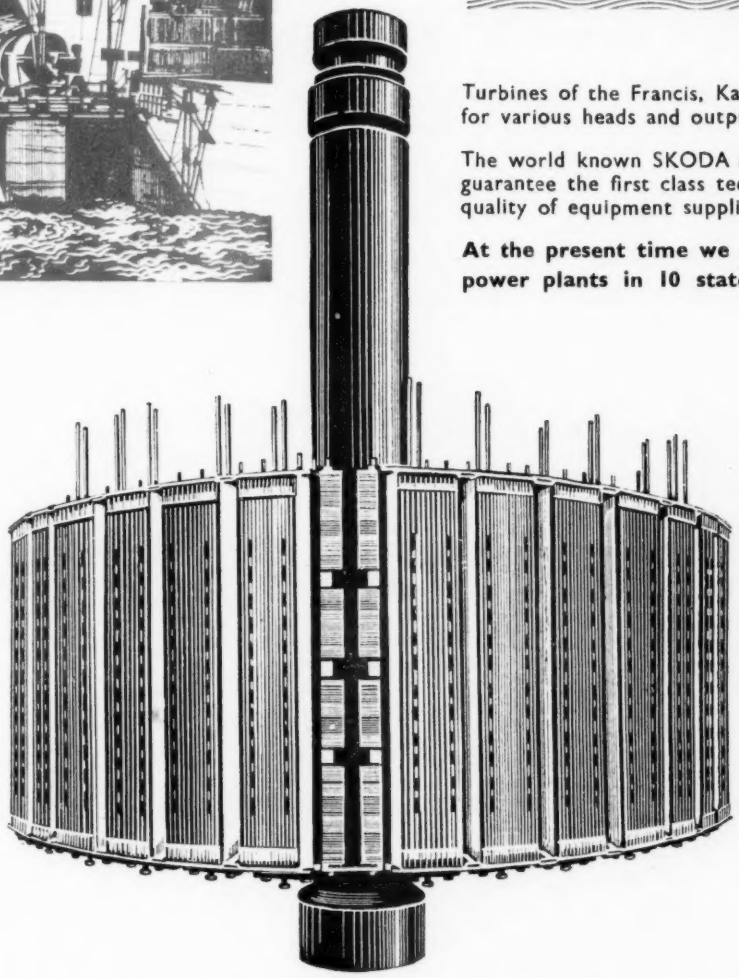

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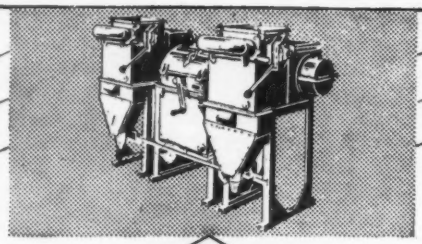

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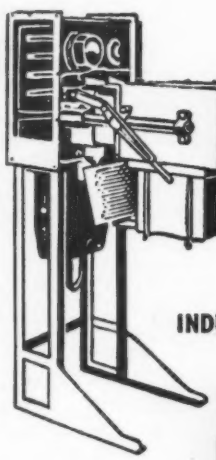

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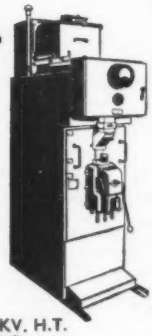

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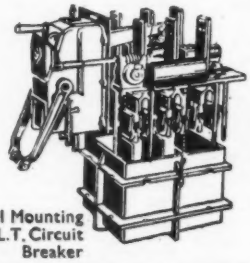

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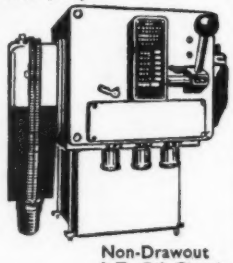

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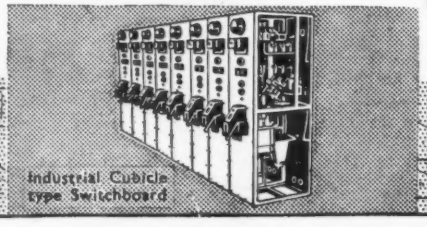

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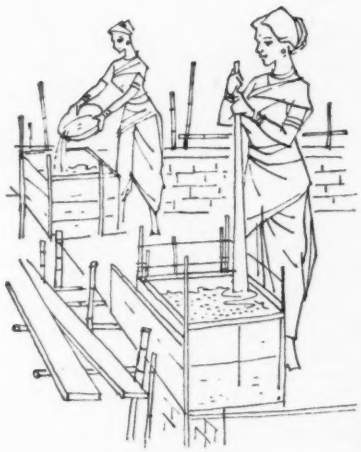

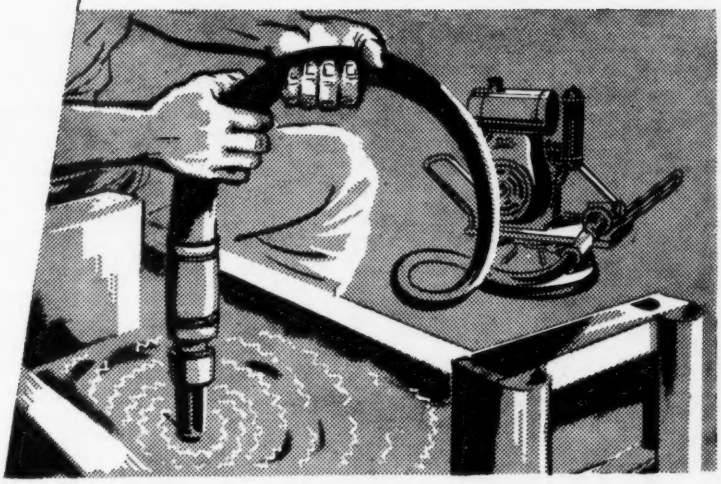

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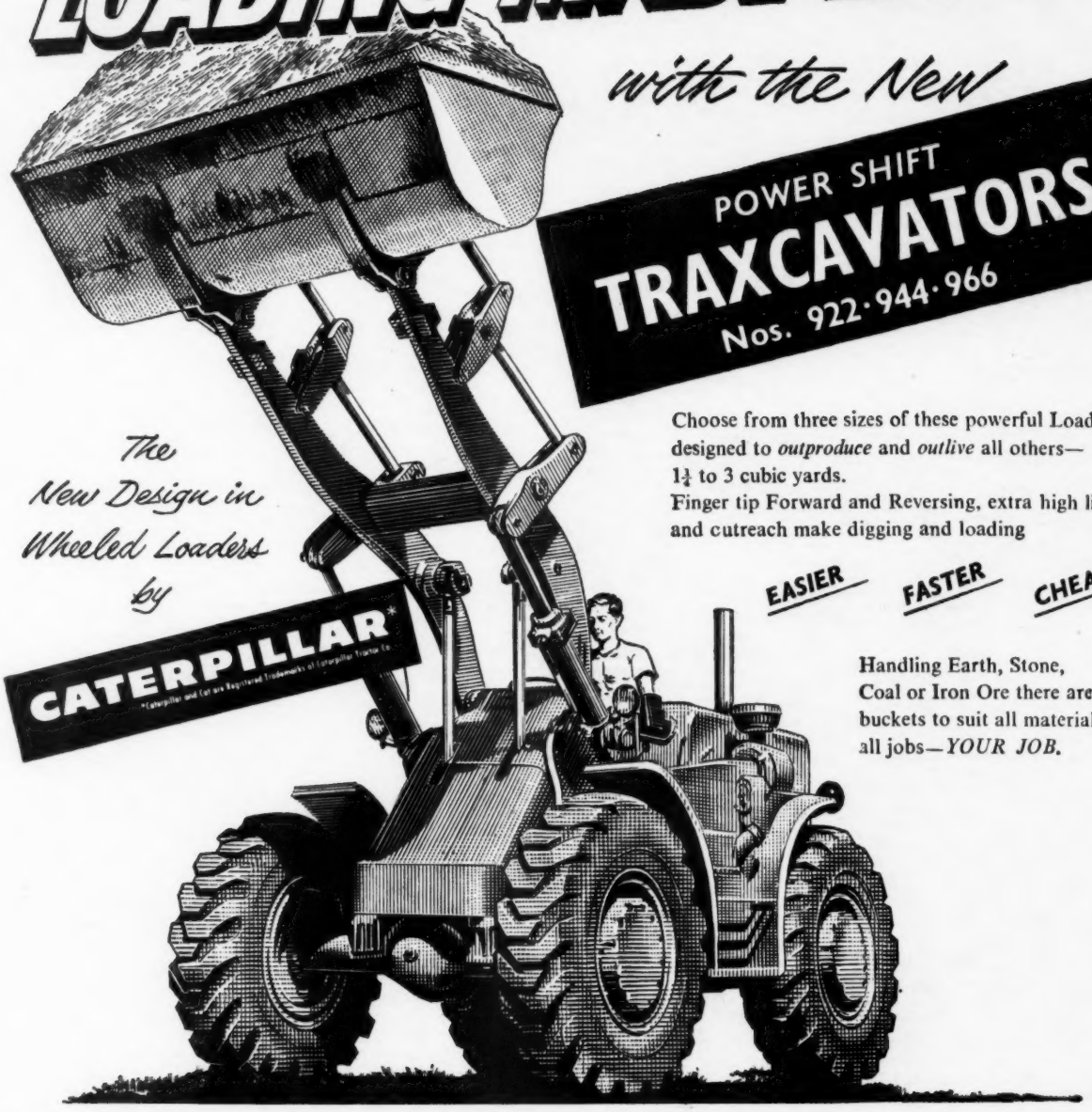

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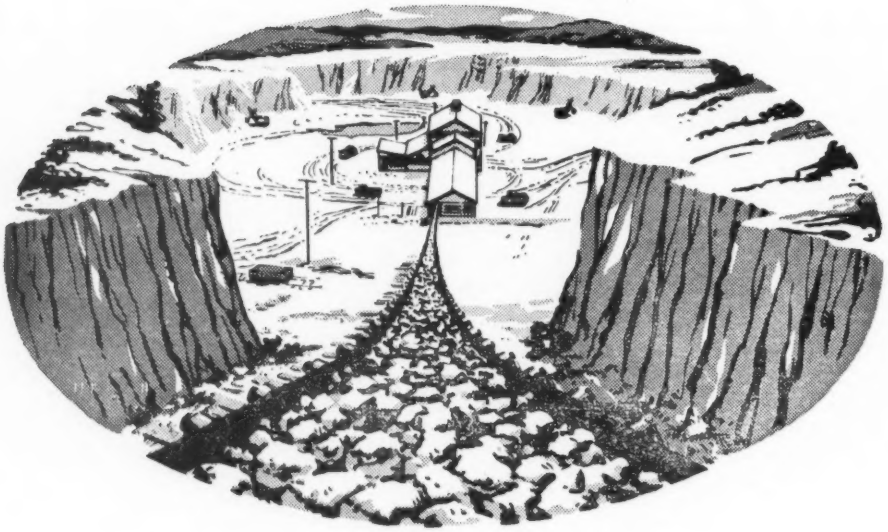

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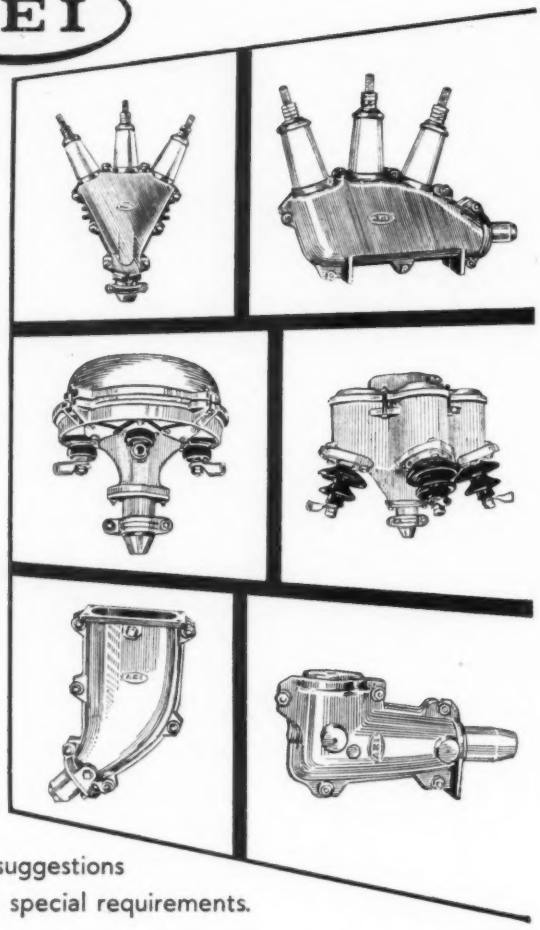

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Power Schemes in the Third Plan in Madras State

DURING THE FIRST FIVE YEAR PLAN (1951-56) the Madras State Electricity Department spent on power Rs. 31 crores out of a total state expenditure of Rs. 86 crores (35%). During the Second Plan the expenditure on power schemes came to Rs. 77 crores out of a total plan provision of Rs. 189 crores (41%). The proposals for the Third Plan on Power amounts to Rs. 100.19 crores out of a total provision of about Rs. 219.89 crores, that is, power projects contribute nearly 45 per cent of the total outlay of the Third Plan. The names of schemes proposed under the Third Plan, their estimated cost, plan provision, approximate foreign exchange requirements and the benefits etc. are given in the Annexure.

Apart from the above, it may be necessary to set up in the Third Plan a Nuclear Power Station in Madras State to meet the large deficit in power even after completing the Third Plan schemes. This is being pursued with the Central Government separately.

The plan in general consists of three spillover schemes for which a provision of Rs. 319 lakhs has been made and eight new schemes amounting to Rs. 9,700 lakhs.

The spillover schemes consists of Periyar Hydro Electric Scheme, Kundah I & II Stages and Sandynallah Reservoir Scheme. All works connected with the Periyar Hydro Electric Scheme have been completed during the Second Plan period itself and the power station with an installed capacity of 105,000 kW commissioned during the third year of the Second Plan. Under the Kundah Hydro Electric Scheme, the two power stations with a total installed capacity of 180,000 kW came into operation during the 4th and 5th year of the Second Five Year Plan. Thanks to the Government of Canada who gave a generous aid to an extent of $ 25 million under the Colombo Plan towards the equipment for the Kundah power stations, the scheme materialised in a record time of a little over 3½ years. The Sandynallah Scheme, which on completion will enable additional generation on the existing Pykara and Moyar power stations is still in progress. Building masonry for the dam and the erection of the pump houses etc. are half-way through in these projects. This is expected to be completed by the middle of 1962.

New Schemes

Of the eight new schemes included in the Plan, four are generation schemes which will increase the installed capacity from 571 MW to 1041 MW. They are

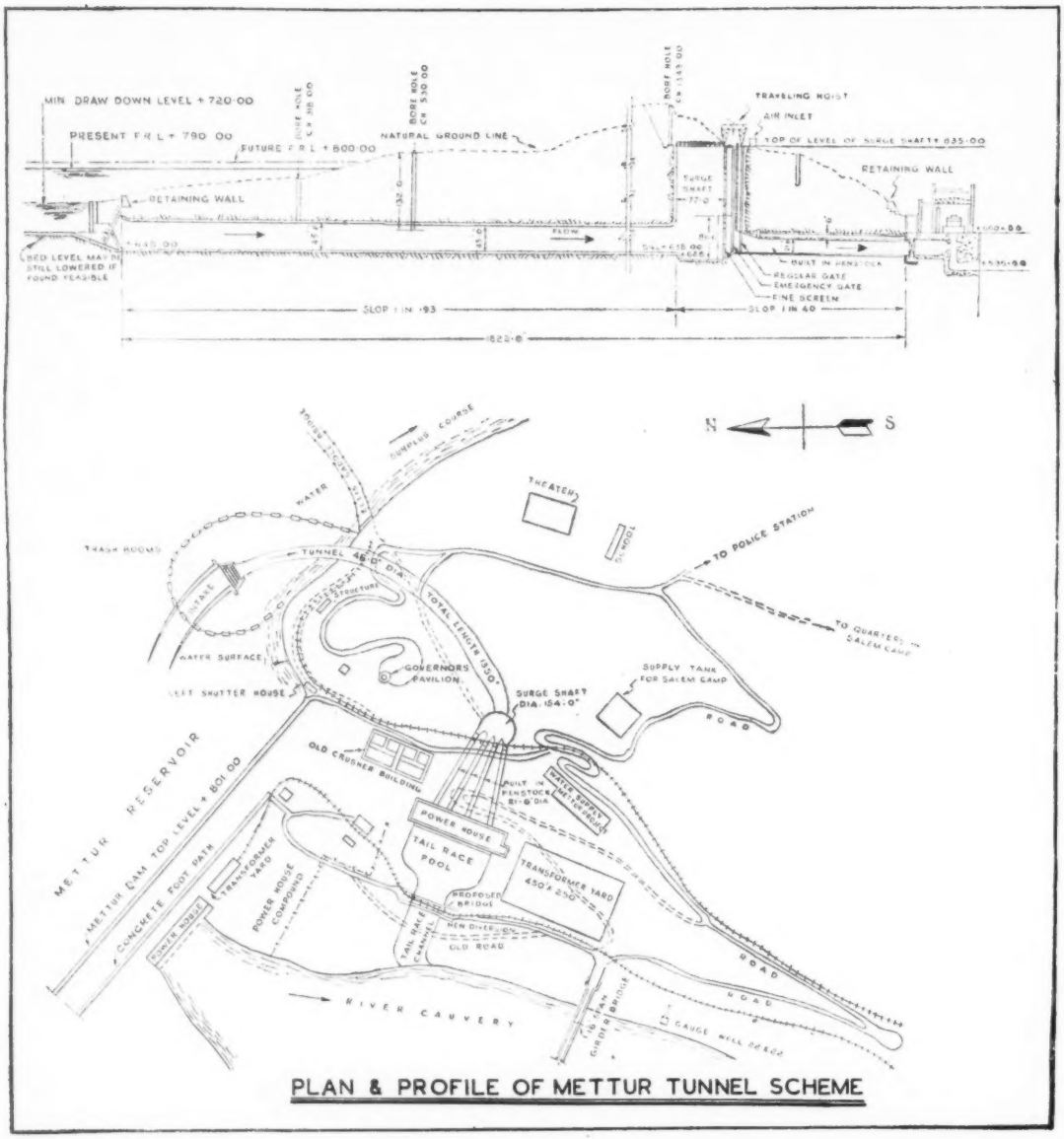
1. Mettur Tunnel Hydro Electric Scheme
2. Kundah Hydro Electric Scheme—3rd Stage Extensions
3. Periyar Hydro Electric Scheme—2nd Stage Extensions, and
4. Annamalai Hydro Electric Scheme.

Mettur Tunnel Hydro Electric Scheme

The Mettur Tunnel Scheme now under execution is to utilise the irrigation discharge of the Mettur Reservoir for generation of power. The present power house at Mettur which is in operation from 1937 utilises a discharge of 4,000 cusecs (out of a normal irrigation discharge of 25,000 cusecs) for generation of power. The present scheme is to utilise the balance discharge of 20,000 cusecs for generating power to an extent of 200,000 kW. The scheme has been prepared in two stages and the first stage of the scheme is now under execution. The 1st stage of the scheme is as follows :

A leading channel of 500 ft. long will be cut from the bed of the Mettur Reservoir to the tunnel entry, which will be located between the existing Mettur Dam and Ellis surplus saddle on the left flank and about 600 ft. from the Dam and about 100 ft. away from the right abutment of the Ellis saddle. The tunnel which is 1350 ft. long and 45 ft. dia. will be cut in rock and will be a cement concrete lined one of a circular shape.

The tunnel ends in a surge shaft 200 ft. deep cut in rock. It will be of a semi-circular shape. The surge shaft is also a concrete lined one. Initially two penstock pipes embedded in rock tunnel will be laid. Each penstock pipe is designed for a discharge of 5,000 cusecs. Two more will be added later on. The internal diameter of the penstock will



PLAN & PROFILE OF METTUR TUNNEL SCHEME

be 21 ft. 6 in. Each penstock feeds individual turbines in the power house.

The power station is designed to accommodate, initially, two numbers of 76,000 HP Kaplan turbines each coupled to 50,000 kW generator. Power will be generated at 11 kV 3-phase 50 cycles and stepped up to 230 kV through two 55,000 KVA 11/230 kV transformers. Each of the generators will be directly connected to its power transformer and operated as an unit system. The transmission system will include 25 miles of 230 kV single circuit line from the tunnel scheme power house to the existing 230 kV substation at Salem.

The estimated cost of the sanctioned scheme works out to Rs. 507.78 lakhs initially rising to Rs. 598.30 lakhs at the end of the four years. A net revenue return of 15.8% is expected from the 4th year of the operation of the scheme.

The scheme was inaugurated in August 1960, by Sri K. Kamaraj, Chief Minister, Madras, and the works are in good progress at the different sites. Excavations are in progress at the power house site, surge shaft site and penstock exit sites. Mining of the tunnel is progressing fast.

The power generating machinery and crane etc. are being supplied from Russia on rupee pay-

ment basis and it is expected that the station will come into operation by the end of 1963.

Kundah Hydro Electric Scheme—3rd Stage Extension

The Kundah 3rd Stage Extensions Scheme now contemplated envisages two more power houses, down below, utilising the waters of the same Kundah river along with other tributaries, another new power house at the exit of the Upper Bhavani Tunnel and additional generators in the existing two power houses. The total fall in the Kundah river that would be available for power generation is about 5333 ft. of which 3647 ft. drop was utilised in the first two stages already completed. The balance of 1686 ft. is proposed to be utilised in two more power houses under the present extensions scheme.

A plan and profile of the scheme is given below :

The extensions scheme generally comprises :

(a) a masonry foreby dam across Pegumbahalla stream just below power house No. 2,

(b) a low pressure tunnel, 36,000 ft. long fully lined from Pegumbahalla forebay dam to surge shaft No. 3,

(c) two penstock lines each 3660 ft. long to power house No. 3 from surge shaft No. 3,

(d) power house No. 3 with 2 nos. of 86,000 HP impulse type turbines each coupled to 60,000 kW generators with a space provision for a similar 3rd set,

(e) Pillur dam (a masonry dam) across the river Bhavani at Pillur which will be 266 ft. high forming a reservoir of 1568 M. cft.

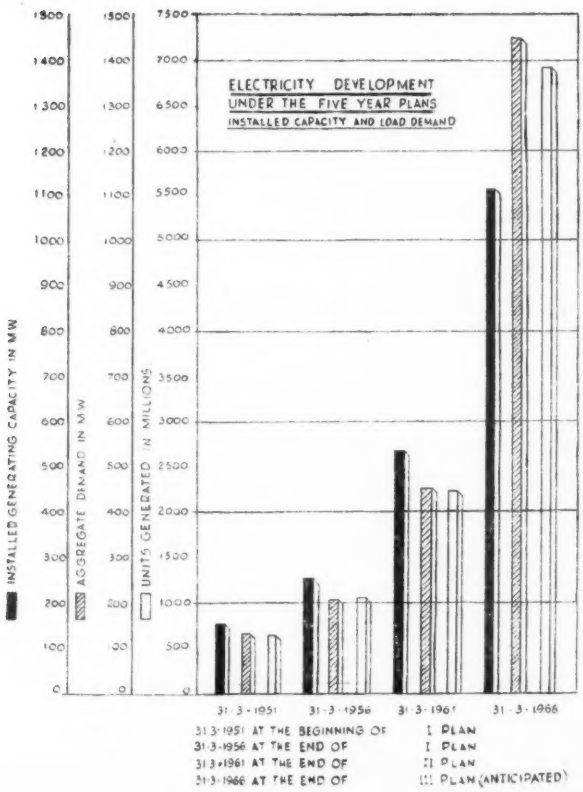
(f) power house No. 4 on the down stream side of the Pillur dam with one reaction turbine of 76,000 HP capacity coupled with a 50,000 kW generator with provision for one similar unit

(g) Erection of an additional penstock line similar to the existing one at Kundah power house No. 1 and one more generator of 20,000 kW

(h) erection of an additional penstock line at Kundah power house No. 2 with one more generator of 35,000 kW

(i) a 5th power house at the exit of the tunnel from Upper Bhavani to Avalanche reservoir with one penstock pipe. The power house will house one turbine of 28750 HP captcity coupled with 20,000 kW generator initially with space provision for one more penstock and generating unit of similar capacity at a later stage.

(j) diversion works and storages at Varahapallam, Sillahalla, Porthimund, Parsons Valley, Kateri, Niralapallam and Western catchments which will have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UNITS GENERATED IN MILLIONS
31-3-1951
31-3-1956
31-3-1961
31-3-1966
31-3-1951 AT THE BEGINNING OF I PLAN
31-3-1956 AT THE END OF I PLAN
31-3-1961 AT THE END OF II PLAN
31-3-1966 AT THE END OF III PLAN (ANTICIPATED)

Fig. 1

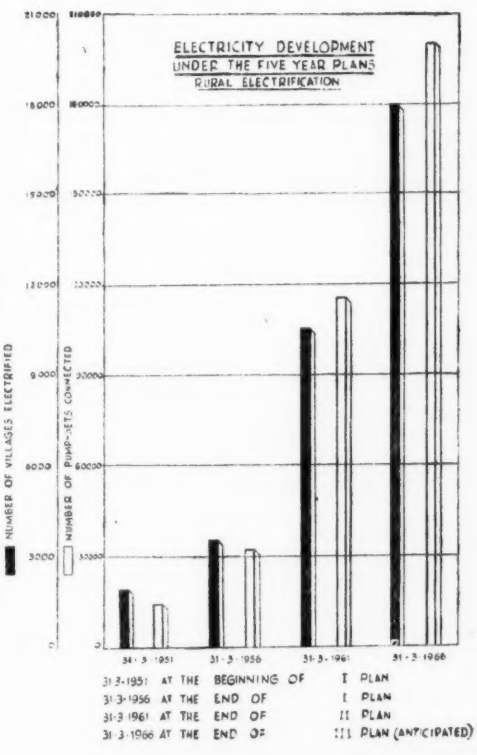
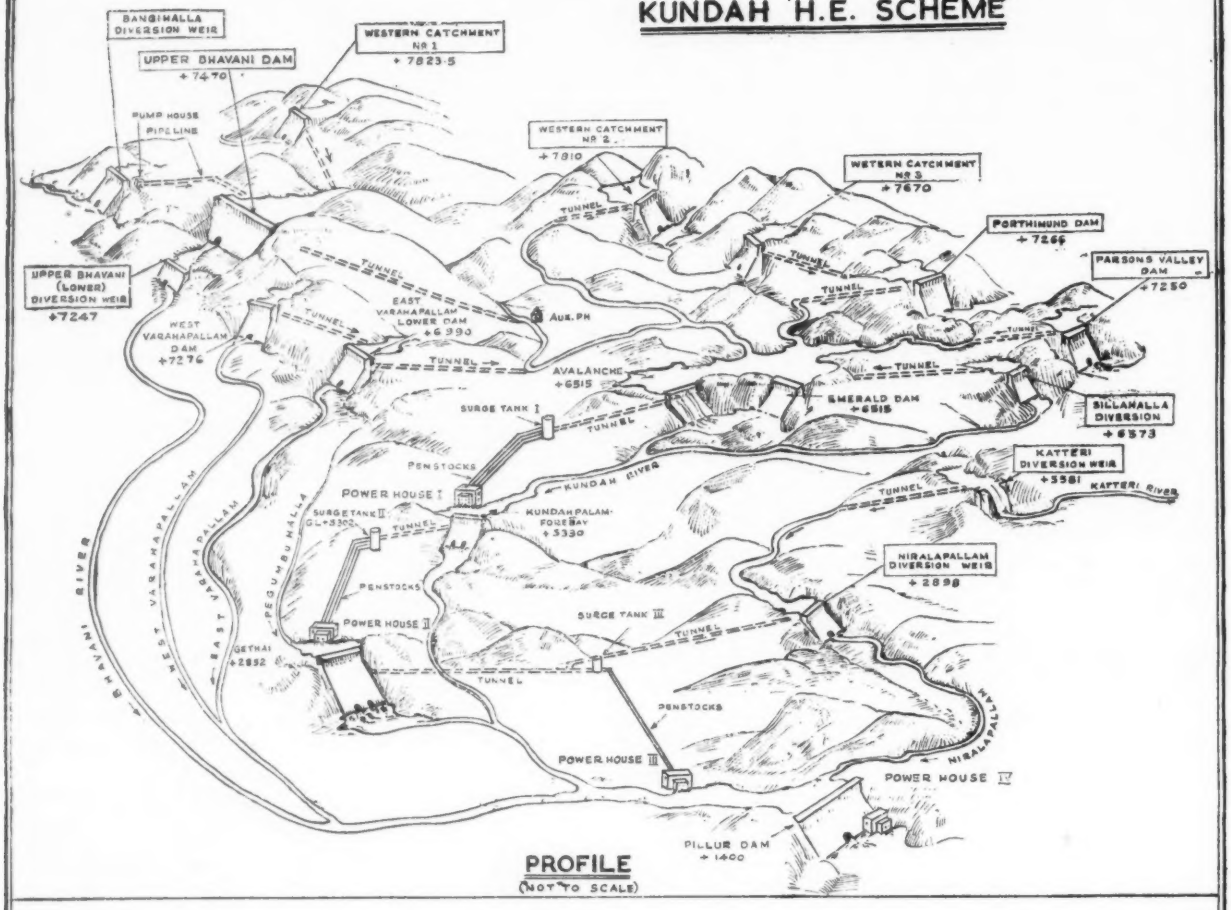


Fig. 2

KUNDAH H.E. SCHEME



PROFILE
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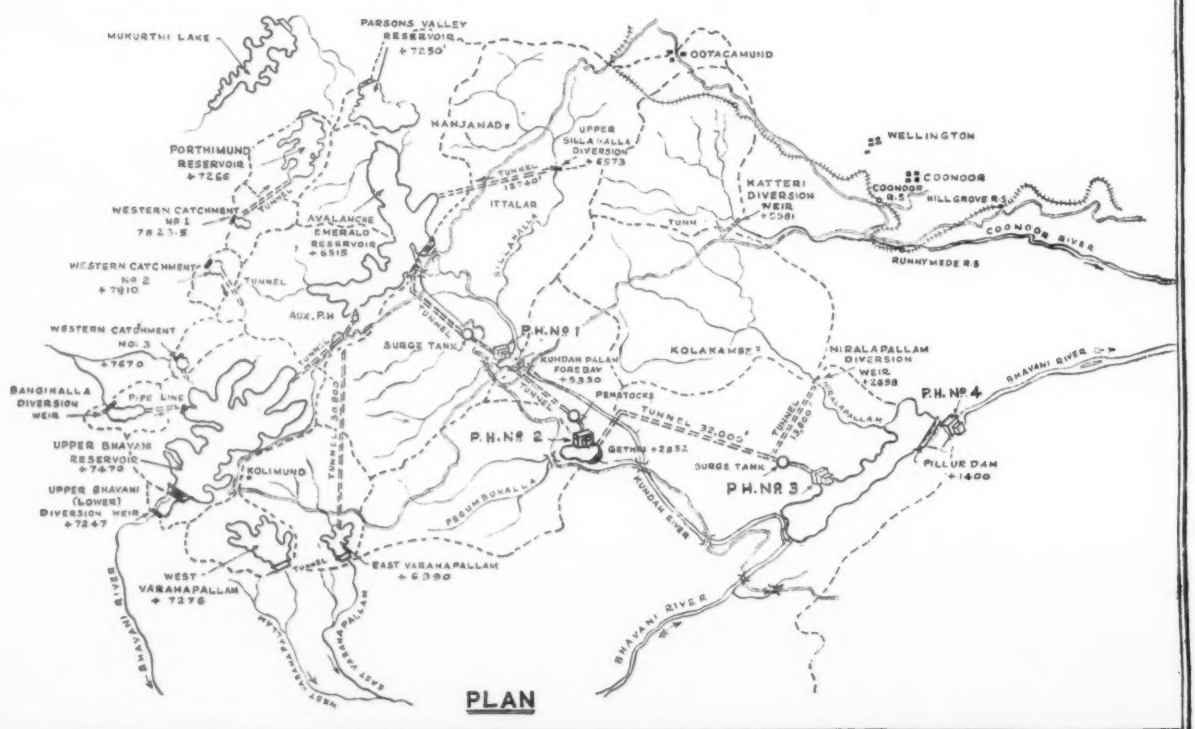


PLAN

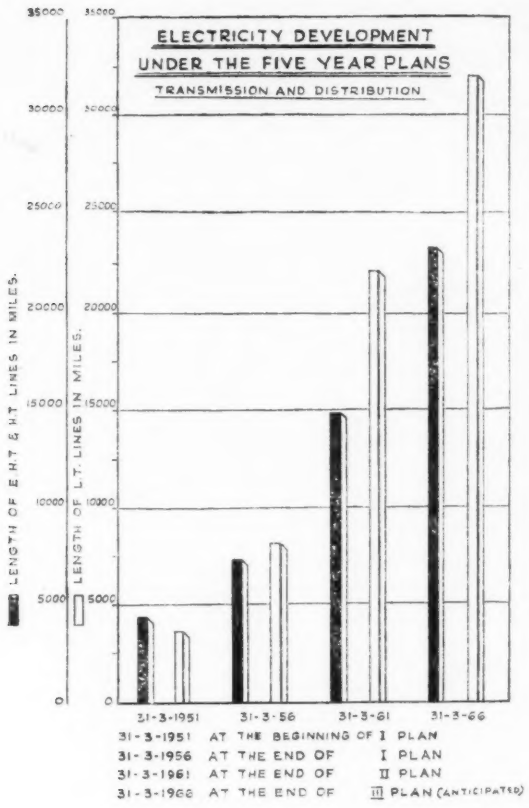


Fig. 3

a total storage of 1840 M. cft. and a number of tunnels totalling to 23 miles in length,

(k) erection of two pump houses with small storages to pump water from Bangihalla catchment and Upper Bhavani catchment below the Upper Bhavani dam to the Upper Reservoir,

(l) a transmission system of 31 miles of 230 kV lines and 69 miles of 110 kV lines with carrier communication and relaying.

The total cost of the scheme is estimated to be Rs. 2305.62 lakhs and the scheme is expected to give a net return of 12.13% from the 3rd year of operation.

The Canadian Government have again generously agreed to give assistance totalling to $ 22 million worth of plant and machinery for this project under the Colombo Plan aid.

The scheme was inaugurated by Hon'ble Mr. Gordon Churchill, M.P., Leader of the House of Commons, and Minister for Veterans Affairs Government of Canada on 18th January, 1961, and the works on the scheme are in full progress at different sites. Excavations at the power house and dam sites are in fast progress and so are the penstock slopes. Work on the seven miles long tunnel 3 has already been commenced.

The Chief Engineer and Technical Member of the Board went to Canada during June 1961, to finalise the specifications for the equipments to be received from Canada under the Colombo Plan and made all preliminary arrangements for the issue of specifications. It is expected that all the three new power stations will start functioning in early 1964.

Periyar Hydro Electric Scheme : 2nd Stage Extensions

The Periyar Hydro Electric Scheme—1st Stage work is one of the schemes executed under the Second Five Year Plan at an estimated cost of Rs. 10.09 crores. The scheme utilises the water from the Periyar lake in Kerala State which has been diverted to Madras State for irrigation purposes, under an agreement signed during the end of 19th century. Utilising a portion of the irrigation discharge, the existing power station generates power to an extent of 105,000 kW with three generating units each of 35,000 kW during the irrigation season.

The present 2nd stage extensions scheme is to utilise the full discharge through the power tunnel

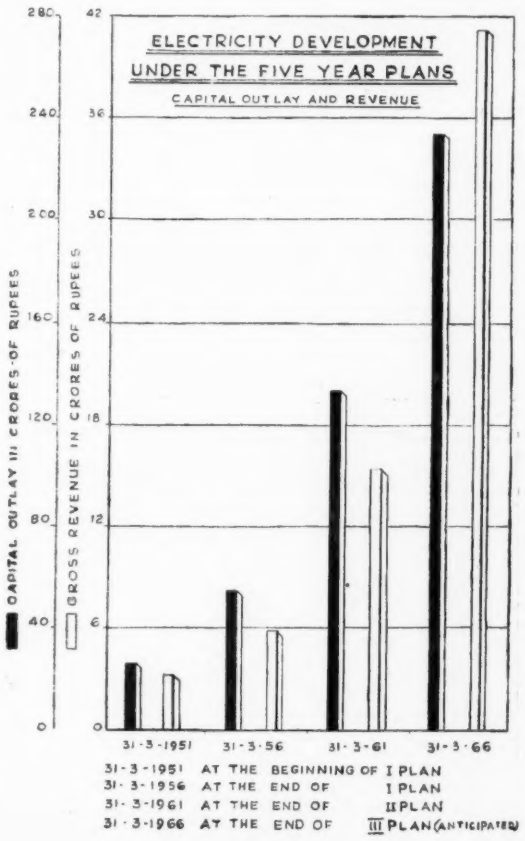


Fig. 4

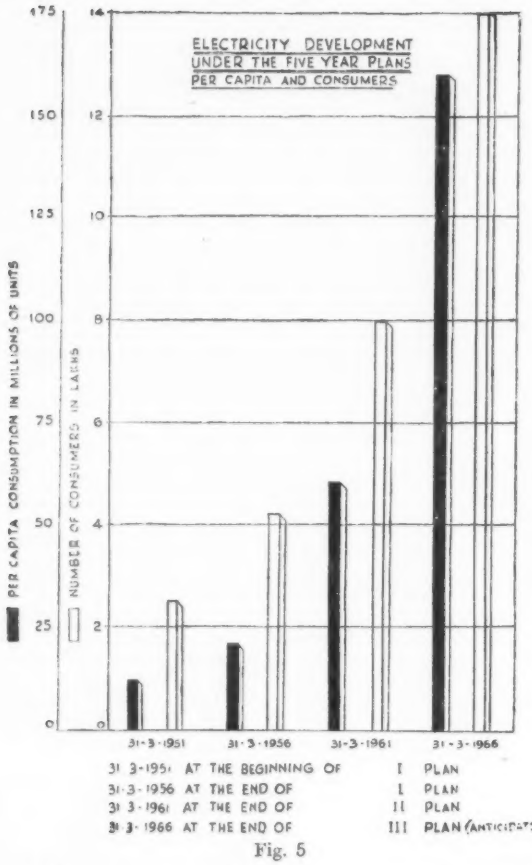


Fig. 5

and install one more 35,000 kW set in the existing power station and connected penstock pipe line etc. in the existing penstock slopes etc. Space provision already exist in the penstock slopes and the power station for these extensions. The capacity of the existing irrigation and power tunnel will be adequate to feel all the four generating units. The scheme is estimated to cost Rs. 94 lakhs and the administrative approval has just been received. The work will be taken up for execution very shortly. By this addition the station will generate 140,000 kW of power during average irrigation season.

Anamalai Hydro Electric Scheme (Parambikulam-Al.yar Project)

This is a combined irrigation-cum-power project. The irrigaton project is being executed by the Public Works Department and the power project by the Electricity Board. The irrigation project as envisaged by the Public Works Department consists of eght storage dams forming six reservoirs at Neerar, Sholayar, Parambikulam, Thinnakkavadu, Palar and Aliyar. These reservoirs are inter-connected through different tunnels of lengths totalling to 9.5 miles.

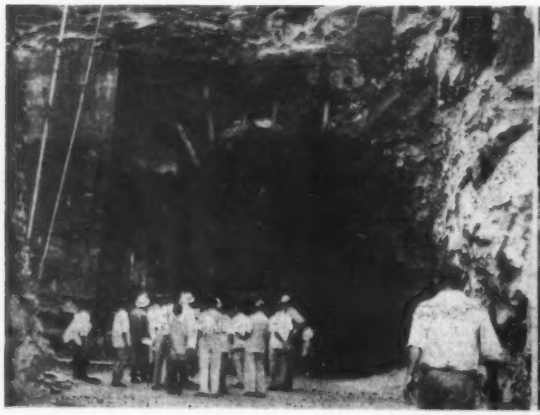
The power project consists of erection of five power houses and the necessary penstock pipes for taking water from tunnels/reservoirs to these plants. The power houses will be located at the following places, with their installed capacity noted against each

Name of the power house.	*Max. gross head in ft.*	*Installed capacity in Megawatts.*
Sholayar	1406	70
Sarkarpatti I	331	30
Sholayar II	575	20
Aliyar I	1004	40
Aliyar II	330	20

The scheme report, costing about Rs. 35.08 crores, for both the irrigation & power project now is under scrutiny with the Central Water & Power Commission. It is proposed to commence the work on the power side immediately after approval of the Planing Commission is received.

Transmission and Distribution Project

A sum of Rs. 30 crores has been provided for the new transmission lines and substations. This



Mettur Tunnel Scheme : Penstock Tunnel

Mettur Tunnel Scheme : Excavation of Power House

Tunnel Power House Site with Mettur Dam at the background

includes the formation of the 230 kV super grid which will facilitate the effective utilisation of power within the State as well as the efficient interchange of power between Madras and its neighbouring states. The super grid includes the erection of a 230 kV line from Neyveli to Singarappet, Neyveli to Trichy and Madurai, and Madurai to Thudiyalur and Kundah. It is also proposed to interconnect Madras and Mysore, and Madras and Kerala through 230 kV net work. A number of 110 kV and 66 kV lines have also been included under this scheme to increase transmission system capacity of the Madras grid. Several new substations and extensions of the existing substations are proposed, to cater to the additional demands all over the State.

Rural Electrification

Since Madras State is predominantly an agricultural State, special impetus has been given to rural electrification during this plan period also on the same lines as the previous years. About 30 crores have been provided for rural electrification works under the 3rd Plan. It is proposed to electrify about 8,000 additional villages in the State during this period. It is expected almost all the villages will be supplied with electric power before the end of the 3rd Plan period.

Loans to Licensees

A sum of Rs. 2 crores have been allotted under this head towards grant of loans for the licensees to extend power to rural areas. This will be allotted to them as and when required so that the rural areas lying under the licensees are not adversely affected in power development.

Investigation of New Schemes

The demand for power is ever increasing and as per the forecast of power requirements made recently, there will be deficit in power of about 500 MW and deficit in energy of 2610 million units in 1965-66. To meet this deficit, new resources of power development are being tapped. About 20 lakhs has been provided for investigation of such new schemes. The following are the schemes that are programmed for investigation during this period :

	Name of Scheme	*District*	*Approximate total power potential at 60% L.F.*
1.	Upper Moyar H. E. Scheme	Nilgiris	20,000 kW
2.	Kodayar H. E. Scheme	Kanyakumari	60,000 kW
3.	Pykara ultimate stage	Nilgiris	40,000 kW
4.	Pandyar Punnapuzha H. E. Scheme	Nilgiris	50,000 kW
5.	Hogenakkal H. E. Scheme	Intersfate between Mysore & Madras	50,000 kW
6.	Kukkalathoraihalla H. E. Scheme	Nilgiris	20,000 kW
7.	Kodarihalla H. E. Scheme	Nilgiris	20,000 kW

These investigations will be carried out by the special

investigation staff working directly in the technical branch.

In addition to all the schemes mentioned above, the Neyveli Thermal Plant coming up shortly under the Central sector, will be supplying power to an extent of 159 MW to the Madras grid. As this will not be adequate to meet the demand in this area, the Neyveli authorities themselves have plans to increase the capacity by 150 MW during the 3rd Plan period. Considering the phenomenal demand of power in the State, even this addition will not cope up to meet the requirements of power. Additional thermal stations may therefore have to come up either under the central sector or under the private sector. The private sector is already planning to have a thermal station here in Madras of about 50 or 100 MW capacity with foreign exchange assistance from private sources abroad. The Madras Government is also pressing its case for an atomic station in the South. It is hoped when these new stations materialise, the power position will improve to a great extent and directly aid the economic uplift of the country.

ANNEXURE

Name of Scheme	*Total estimated cost.*	*Spillover from 2nd Plan.*	*Plan provision*	*Approximate foreign exchange component.*	*Benefits in 3rd Plan in MW.*
(*A*) *Continuing Schemes*					
1. Periyar Hydro Project	1048	12	12	—	—
2. Kundah Stages I & II	3544	248	248	9	—
3. Sandynallah Reservoir Scheme	125	59	59	—	—
Sub total			319	9	
(*B*) *New Schemes*					
4. Mettur Tunnel Scheme	599	—	580	240	100
5. Kundah, Stage III	2306	—	2306	900	240
6. Periyar, Stage III	94	—	94	84	35
7. Annamalai Project (Parambikulam)	559	—	500	275	95
8. Transmission & Distribution	—	—	3000	1372	—
9. Rural electrification	—		3000		
10. Loans to licensees	—	—	200	—	—
11. Investigation	—	—	20	7	—
Sub total			9700	2878	
Total :			10019	2887	470

Note : (i) The Neyveli thermal extensions programmed under the 3rd Plan with an addl. installed capacity of 150,000 kW will be provided for under the Central sector.

(ii) All transmission lines of projects of 2nd Plan and improvement works will be included under item 8.

(iii) Under trtnsmission and distribution, 8000 miles of EHT and HT lines will be erected (including HT lines under item 9).

(iv) Under rural electrification, 8000 addl. villages will be extended supply. This is exclusive of the rural electrification contemplated under item 10.

INCREASING THE PRODUCTIVITY IN SINGARENI COLLIERIES

(*Continued from page* 12)

Shuttle Car combination when worked efficiently gives us a reduction in cost of Rs. 1 to 3/- per ton depending on the underground conditions as compared with hand method.

We have not been able to extend mechanisation to the extent we would have liked because of the problem of surplus labour as stated earlier. Apart from the labour which becomes surplus due to improved management practices we were faced with the problem of about 5,000 workers who were rendered surplus because of closing down of old mines. The problem of surplus labour will continue to limit the introduction of mechanisation for 2 or 3 years more. As greater targets of production would be demanded from our coalfields, this problem will get automatically resolved and we would be in a position to introduce mechanisation to a greater degree.

We are now thinking in terms of experimenting with Ploughs and Armoured Conveyors for thin seam working. It is hoped to introduce one such unit in the near future as an experimental measure.

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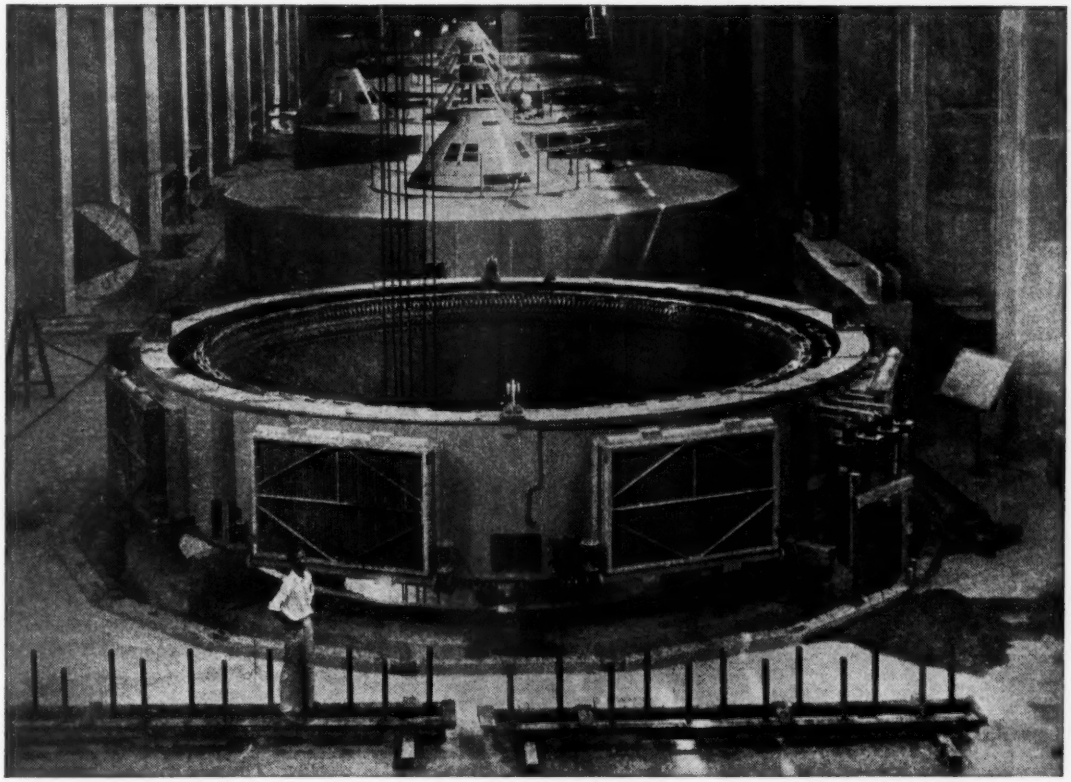

The English Electric Company has supplied five 77,000 B.H.P. Vertical Shaft Francis Turbines coupled to 55,500 KVA, 11 KV Umbrella type Generators for the Rihand Power Station in the U.P. The Company has also supplied all the H.T. & L.T. indoor Switchgear, Control and Relay Boards, Station and Unit Transformers and all ancillary equipment.

The illustration shows the interior of the Power Station with the fifth set under erection.

Every aspect of hydro-electric design and manufacture is dealt with inside the Company's organisation and comprehensive hydro-electric installations in India by 'English Electric' include Sengulam, Radhanagari, Nizamsagar and Sarda Power Stations. Hydro-electric equipment has also been supplied for the Power Stations at Bhira, Hirakud, Poringalkuthu, Papanasam and Mettur.

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MECHANISATION OF MINES IN INDIA — SYMPOSIUM

9th to 12th December, 1961

AT THE

CENTRAL MINING RESEARCH STATION, DHANBAD

Jointly sponsored by the Central Mining Research Station, the Indian Branch of the Association of Mining Electrical and Mechanical Engineers and the Journal of Mines, Metals & Fuels, the Symposium will be the first of its kind in India in which delegates from the U.S.A., U.S.S.R., U.K., France, Germany, Poland, Hungary, New Zealand, Canada, and Czechoslovakia will be participating. There are altogether 68 papers, under five different sections: winning and methods of work, transport, ventilation and blasting, supports, safety and control. Leading authorities as Prof. Atkinson, Prof. Lyden, Prof. Fritzsche, Dr. Roberts, Dr. Damon, Dr. Bihl, Prof. Krupinski, Prof. Mankovsky, Prof. Szlarski, and Dr. Zwanjig, among others, will be attending.

Intending delegates must register their names before 7th November with Mr. S. Bagchi, Deputy Director, Central Mining Research Station, Barwa Road, Dhanbad.

S. K. Nargundkar
General Manager
Singareni Collieries

Increasing the Productivity in Singareni Collieries

The following contribution is based on the Presidential Address by the author delivered on the occasion of the Annual Meeting of the Geological, Mining and Metallurgical Society of India held at Calcutta in August 1961. In view of the importance of coal in the development of the country's economy, this specific experience in the field of mechanisation and raising of productivity in one of India's major coal mines in the South should prove useful to our readers.—Editor.

THE PRODUCTION OF THE SINGARENI COLLIERIES Company Limited for the year 1950 was 11.6 lakh tons. After the Police Action in 1948, the erstwhile Government of Hyderabad under their Industrial Trust Fund Department decided to increase the production from these groups of mines. A plan was prepared in 1950 to increase the production to 15 lakh tons by 1955. In about 1954 it was decided to increase the production further to 20 lakh tons by 1958. At the end of the 1st Five Year Plan it was decided to increase the target to 30 lakh tons by 1961/62.

	Target.	*Achievement.*
1955	1.5 million tons	1.53 million tons
1958	2.0 million tons	2.23 million tons

It is confidently expected that the target of 3 million tons for the year 1961/62 would also be achieved.

It may be stated that during the period 1958 to 1960 that a production of nearly ½ a million tons per year was lost because of closure of old mines due to exhaustion of coal reserves. This was made up partly by intensification of existing mines and also by opening new mines.

The target set for the Singareni Collieries Co. Ltd., for the Third Five Year Plan is 5.6 million tons. During the period 1962/65, it is anticipated that about 1 million tons of production would be lost due to exhaustion of coal in the older mines. This means the Company has to plan to produce from underground mines starting from scratch in new areas, 3.6 million tons in 4 years. We are confident of achieving this target.

I propose to discuss briefly some of the aspects to which Singareni Collieries Company Limited has paid special attention.

PRODUCTIVITY

In the year 1950 when the present maganement took over it was found that the productivity of Singareni Collieries was low, being only 0.25 tons per manshift. The management took a decision to raise the productivity through a bold experiment of work study and the application of Industrial Engineering Techniques, the broad concept being to raise productivity from 0.25 tons per manshift to 1.0 ton per manshift. In some of the newer mines, productivity has already reached 0.75 tons per manshift.

The productivity in Coal Mining Industry in various countries is given below :—

	tons per manshift.
U.S.A.	8.50
U.K.	1.25
West Germany	1.19
S.A.A.R.	1.16
France	1.08
Netherlands	0.96
India	0.41
U.S.A. (Bituminous lignite) ...	10.79

We took the assistance of IBCON to help us in achieving the envisaged goal of higher production and productivity and established the Department of Industrial Engineering in the year 1951.

At Kothagudium one of the three groups of our coal mining areas the result of productivity drive in the past decade is as follows :—

	Men on Roll			
Year.	*Productive.*	*Non-productive.*	*Total.*	*Output Tonnage.*
1951	3,175	9,001	12,176	8.40 lakh tons
1961	4,755	7,401	12,156	12.40 lakh tons (estimated for Oct. to Dec.)

It will be seen from the above table that for 10 years (1) the number of men has been held steady ; (2) the ratio productive to non-productive workers is changing for the better and (3) with the same number of men, the production has gone up by 50%.

In reaching the present targets, application of industrial engineering techniques, besides the mining techniques, have contributed in raising productivity and I will now deal broadly with some of the steps taken.

Firstly, we discussed with the labour unions the broad concept of raising productivity at our mines which in a nutshell meant increasing production by over 100%, raising earnings of workers by 60% and completing the task by rationalisation without tears. We further guaranteed that not a single worker will be retrenched, but those found surplus will be gradually deployed in more beneficial activity and thus removed the fear of unemployment thereby creating conditions satisfactory for the application of the industrial engineering techniques.

The magnitude of the job can be gauged by the fact that by 1960/61 not only 2.5 million tons of coal had to be produced but also during the course of the execution of this production drive some of the older mines were nearing exhaustion due to the coal reserves being completely worked out and by the end of 1960 the production from three such mines namely No. 4 Incline, Birley Pit and No. 3 Incline at Kothagudium was lost. No. 4 Incline was closed in February 1958, Birley Pit in December 1959 and No. 3 Incline in May 1950. The most important problem which the Management of the Singareni Collieries had to face was the rehabilitation of about 5,000 workers from these mines. This operation meant not only finding new jobs for these men but also finding housing accommodation etc. for them in the new areas. It was like moving a township from one location to another. The output at Kothagudium had thus to be increased not from 8.4 lakh tons per year to 12 lakh tons per year but when you take into account the 56% loss in production due to closing mines, the increase in effort is from 3.7 lakh tons to 12 lakh tons i.e. about 250%.

The increase in productivity has been made possible by :

(a) Overall labour control on recruitment and settlement.
(b) Systematic workstudy.
(c) Incentive plan for labour for increasing production and productivity in the mines.
(d) Opening new mines to (i) compensate the losses in output due to closure of old mines and to (ii) intensify production in older mines.
(e) Standard staffing of new mines from the initial stages.
(f) Mechanisation of the mines wherever possible.
(g) Training and utilising labour who have been rendered surplus due to workstudy or otherwise, in the vacancies arising out of normal wastage or in connection with the expansion scheme.
(h) Reorganisation of existing methods of transport and surface layouts including redesigning of surface screening plants.
(i) Material consumption standardization.

Labour Training Pool

As a practical means of reducing surplus labour, the Company established a Labour Training Pool in 1951. Surplus labour from Mines and Departments when they could not be directly transferred to where they were needed were first sent to the Training Pool and given the necessary training and then sent to new mines and vacancies.

About 3000 people were sent to the Labour Training Pool during the last few years and about 2500 have been sent out to new jobs. The present strength of the Pool is approximately 500. Direct transfers without workers being sent to the Pool during the same period were of the order of 5000.

Incentive Schemes

Some of the members may be interested in the actual results obtained by introducing incentive plans as a result of work studies in the mines. A number of categories of workers in groups in various mines are studied. As an example, I give below some of the results achieved in a tabular form :—

1. *Coal Fillers* : The results of this incentive scheme is tabulated in the following table :

Mines.	*Performance Index %*		*Manshifts per 100 Tons.*		*Incentive as a % of basic wage.*
	Ref. period.	*Current.*	*Ref. period.*	*Current.*	
1 Incline	32.0	55.2	890	526	39.2
2 Incline	36.0	38.5	686	671	26.6
5 Incline	37.0	39.8	634	590	26.8
7 Incline	34.8	44.1	670	530	31.6
8 Incline	37.3	37.5	660	625	23.3
10 Incline	36.0	41.0	650	578	25.0
11 Incline	32.0	39.9	730	585	19.5
Overall	35.2	41.8	715	582	27.3

The overall manshifts of fillers per 1,000 tons has come down by about 25%.

2. *Trammers* : The table given below indicates the results of incentive on tramming allocation :

Mine.	*Performance Index.*		*Incentive as a % of basic wage.*	*Remarks.*
	Ref. Period.	*Current.*		
	1.	2.	3.	4.	5
No. 1 Inc.	33.0	57.2	32.2	
No. 2 Inc.	43.5	52.4	10.9	
No. 5 Inc.	47.0	63.5	30.6	
No. 6 Inc.	40.0	43.3	16.7	
No. 7 Inc.	40.0	47.4		
No. 8 Inc.	25.2	18.3	—	New developing mines not enough working places.
No. 9 Inc.	24.5	25.8	0.8	
No. 21 Inc.	37.8	51.6	24.8	
Overall.	36.6	51.5	21.2	

The overall tramming manshifts per 1,000 tons has come dow from 343 to 228 i.e. about 34%.

3. *Screening Plants* : The following table gives the details of the working of these plants :—

Details.	*Performance Index.*		*Manshifts per 100 tons.*		*Incentive.*
	Ref. Period.	*Current.*	*Ref. Period.*	*Current.*	*as a % of basic*
No. 5 Incline—Screening Plant	44.1	55.0	72.5	50.0	20.5
No. 2 Incline—Screening Plant	46.0	69.0	58.1	33.4	40.0

4. *Coal Cutters* : The following table gives the summary of the trend of the working of the wage incentive plans for Coal Cutters of all the mines at Kothagudium. Coal Cutters are drillers, who drill holes with hand-held electric drills for blasting coal :—

	Performance Index.		*Mondays per 1000 tons.*		
	Ref. Period.	*During 1960.*	*Ref. Period.*	*During 1960.*	*Remarks.*
No. 1 Incline.	25.5	30.6	558.30	428.00	
No. 2 Incline.	21.6	26.4	383.40	254.00	
No. 5 Incline.	28.5	37.2	308.80	238.00	
No. 7. Incline.	24.0	33.7	257.00	235.00	
No. 8 Incline.	30.8	30.3	226.00	230.00	Non-availability of enough No. of working faces has resulted in drop in performance.
No. 9. Incline.	33.5	29.8	207.00	233.00	
No. 21 & 24 Pit Inclines.	21.0	29.2	535.00	340.00	
Overall.	23.0	31.6	395.00	270.00	

It can be seen that the manshifts per 1,000 tons has come down from 395 to 270 i.e. a reduction of 31.5%.

5. *Powder factory. Powder filling section* : The following table gives the summary of the trend of the working of the wage incentive plan for gun powder filling section :—

Period.	*Performance Index %.*	*Output in lbs. filled.*	*Incentive bonus as a percent of basic wage.*
Reference period	44.0	125 lbs.	—
During 1960	86.0	350 ,,	65%

It can be seen from the above table that the output per manshift has increased by 180%.

6. *Workshop* : Incentive in workshops are mostly paid on increased performance. To quote an example the Foundry Section which was producing only 9.14 tons of ferrous casting per month had gone upto 20.00 tons of ferrous casting with the same staff. The overall trend indicates an increase in performance in every section. The following table gives the details :—

Section.	*Performance Index. Ref. Period.*	*Current.*	*Incentive as a % of basic wage.*	*Remarks.*
1.	2.	3.	4.	5.
Tub Repairs	28.1	44.5	16.3	
Log Saw	28.4	38.8	14.8	
Foundry	28.8	34.1	8.6	
Smithy	26.0	30.6	9.8	
Machine Shop	17.0	25.6	16.7	

When the first studies on productivity and the payment of incentive bonus were made, there was some opposition from the labour unions. The contention of the unions was that an increase in productivity meant an increase in work loads. This opposition was got over by persuasion and discussions and explaining that the workers really stood to gain by increased production and productivity.

About 13,500 workers have so far been studied out of about 25,000 workers and we are paying about Rs. 55,000/- per month on incentive schemes.

Effects of Incentive Schemes : These incentives have resulted in an increase in the output of effective work of the employees. They have provided to the Management a sound basis of labour control, as changes in the levels of performance of workers are measured and made available. This has also provided a consistent and acceptable means of rewarding an employee for the increase in his own effective contribution of work. In turn the employees have been provided an opportunity to earn for themselves and their dependants a higher standard of living in the form of increased purchasing power.

The incentive schemes properly designed and administered have several important indirect results which are difficult to evaluate. They can effect a tremendous improvement in the labour turnover, absenteeism, management-labour relations etc.

I may add with satisfaction that our workers and the unions have reacted favourably to this during the last 8 or 9 years and now there is a demand from the workers themselves to bring them under Incentive Schemes by studying their performances. In

certain instances, the workers themselves surrendered the surplus labour. This is a very happy trend.

Mechanisation

Indian economy is still considered to be in the bullock-cart age or just getting out of it. We are just entering the bicycle age. We have a long way to go to catch up with the advanced countries of the world. Our coal mines are still in the basket-age. In many mines it is still a basket-khapchori age (a piece of mild steel sheet about 12" to 15" by 6" to 8") and not even a basket-shovel age.

The III Plan target for the country is 97 million tons by 1965/66 as against an achievement of about 54 million tons by 1960/61. This is a big jump and we are already thinking in terms of 170/180 million tons for the IV Plan. Such big jumps in production cannot be achieved without mechanisation of a very high order.

There is a welcome trend throughout the country to go in for more and more mechanisation. It has been the policy of Singareni to mechanise their collieries to the maximum extent possible. The term "Mechanisation" in coal mining means different things to different people. In general introduction of coal cutting machines is considered by many to be mechanisation. I have used the term mechanisation in a wider sense to mean complete mechanisation from face to the wagons, i.e. coal to be produced almost untouched by hand. To do this the Company introduced Joy loaders, shuttle cars and underground conveyors in the year 1950 in one of their Inclines, as an experimental measure. This experiment was a success and No. 5 Incline at Kothagudium Collieries was planned in such a way as to get the coal from the face to the wagons whenever needed. The working districts were equipped with coal cutting machines, Joy loaders drilling machines, shuttle cars and gate belt conveyors. Singareni Collieries were pioneers in introducing such a complete unit in their mines. The first such unit was put underground in the year 1950. Belt conveyors were also provided along the trunk roads right up to the raw coal bunkers of the screening plant on the surface.

As a natural corollary to underground mechanisation surface coal-handling arrangements had to be fully mechanised.

A big screening plant capable of handling up to 4,000 tons a day with overhead bunker capacity of approximately 4,000 tons was also erected as stated earlier. Overhead bunkers were provided to take care of irregular wagon supplies. This plant costing about Rs. 30 lakhs was designed, fabricated and erected by the Colliery engineers in a record time of about 18 months starting from foundations.

Other steps that were taken to make mechanisation a success are briefly mentioned below :—

Training : To make mechanisation a success the training of Joy loaders and shuttle car crew was an important factor. To do this efficiently, training galleries on the surface were built reproducing underground conditions. This was a great help in the beginning particularly in the handling of the shuttle cars round 60° to 90° bends.

Workshop : A repair and maintenance workshop and a special store for spare parts of machine mining section was attached to this training centre.

Lamp rooms : Another aspect that received attention was mine lightning. Prior to 1950 all the mines carried open kerosene lights (Mug-bathies). These open lights gave more smoke than light and polluted the mine atmosphere too. We took an important step in 1952 in deciding to equip all our mines with electric Cap Lamps. This was a big decision to take at that time, as there was a genuine fear that the India miner may not like Cap lamp and might prefer a hand lamp, particularly as he was not wearing a helmet. We decided to take the risk and went in for a big and modern self-service type of lamp room capable of holding 2,500 lamps at No. 5 Incline. This was the biggest lamp room of the type in the country at that time. Incidentally this pioneer installation went a long way to help to establish a cap-lamp manufacturing industry in Madras.

This lamp room has been a success right from the beginning and our illiterate miners take their own numbered lamps and keep them at the proper places at the end of the shift as in any advanced mining community. Most of the men have also started wearing helmets which is an additional advantage.

Roof-bolts : In trackless mining, where heavy machines have to move about timber to support roof would be difficult and may even be a source of danger. Roof-bolting was therefore introduced about the year 1952, I believe for the first time in India and has been a success. We make our own roof bolts and at present we are using about 1500/2000 bolts a month. We have used more than one lakh roof-bolts so far with success.

Results of Mechanisation

In developing sections the average results obtained with Joy Loaders and Shuttle Cars are of the order of 3 tons per manshift. When conditions are good even results upto 10 tons per manshift have been obtained during certain weeks . Efforts are being made to introduce Joy Loaders and Shuttle Cars in depillaring sections in conjunction with sand stowing. The method of working is being finalised by discussion with the Mines Department, whose attitude has been helpful. It is confidently hoped to achieve face O.M.S. of about 10 tons when this scheme gets going properly.

Scraper Chains with Joy Loaders were also tried in certain section to a limited extent. They did not prove to be as successful as the Joy Loader Shuttle Car combination under our conditions.

Our present experience shows that the Joy Loader

(*Continued on page* 8)

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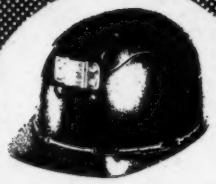
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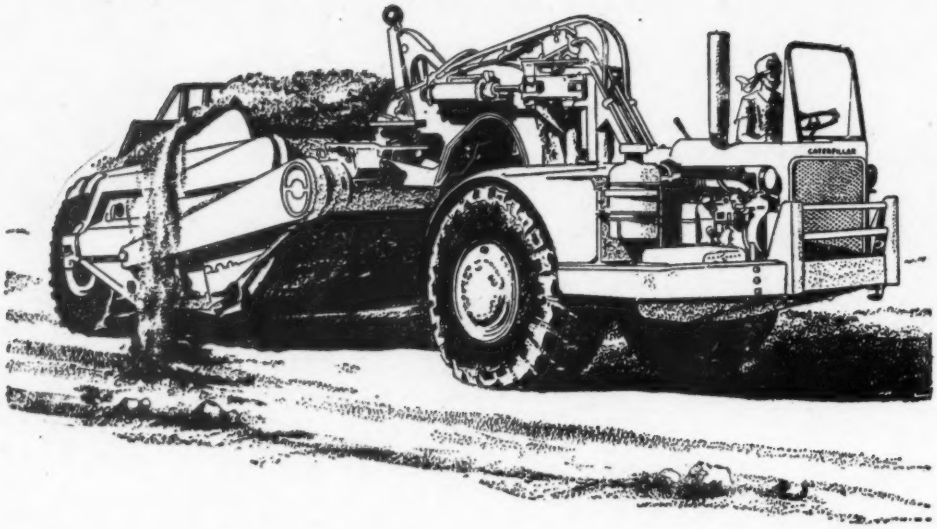

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Sub-Surface Investigations for Dam Sites

CONSTRUCTION OF A DAM CAN BE CALLED A project of very serious responsibility in the public sector which requires thorough investigations for its successful execution. As these investigations generally involve an examination and study of several prospective sites in order to determine the most suitable site with respect to safety, engineering practicability and economic feasibility, and then a through investigation of the finally selected site, they are carried out in two stages : preliminary and final (Ref. 1 & 2).

The purpose of the *preliminary investigations* is to provide sufficient information to confirm the practicability of any dam construction scheme, to compare and choose between alternative sites and to prepare preliminary designs and estimates. The *final investigations* (Ref. 1) comprise the detailed investigation of the finally recommended site so as to establish beyond doubt its complete suitability and to enable final designs, estimates and specifications to be prepared with the least chance of any serious alteration afterwards.

Preliminary Investigation

The preliminary investigations generally include the following studies : (a) General reconnaissance and topographical studies, (b) Hydrological studies, and (c) General sub-surface exploration. As a result of these studies it is possible to select the most suitable site and to prepare preliminary designs and estimates.

The object of general reconnaissance is to locate first all possible dam sites for the proposed construction and then to eliminate as many of them as practicable on the basis of superficial geological investigation, topography and perhaps a little subsurface exploration. This work should be carried in collaboration between the civil engineer and the geologist. Before commencing reconnaissance tours of the ground it is essential to collect and study already existing information like aerial or ground surveys, any geological report or any previous relevant report. The already existing topographical information should be supplemented by undertaking aerial, tacheometric or others surveys. With the recent developments, aerial surveying (aerial photogrammetry) plays an important part in the reconnaissance. Reconnaissance should also include a field examination of materials deposits. Areas should be traversed with the aid of air-photos, topographic maps and notes taken on the location and estimated quantities of construction materials which show promise. No test samples are usually collected at this stage. River banks, highway and railway line cuts will usually disclose the character of the subsurface materials. Topography, vegetal cover, and accessibility, which will influence the methods and equipment used in construction should be noted. Other useful information which may be obtained during reconnaissance is described in detail elsewhere (Ref. 3 & 4).

Preliminary hydrological studies aim at obtaining overall rainfall and run-off data, principal river flow data, and flood charcteristics etc. Detailed description of hydrological investigations is considered beyond the scope of this paper.

General Sub-Surface Exploration

General exploration is carried out of the foundation material (overburden and bed rock) at the most feasible dam site (or sites) and of the sources of materials of construction. The exploration should yield such geological and soil engineering data which will be of help in weighing the practicability of various competitive sites (if such is the case), selecting the most suitable site and in preparing preliminary design and estimate so that the investigations may be carried to the *final* stage.

Foundation Exploration

Foundations for a dam structure fall under two classes (a) Alluvium foundations—when dam is founded on the overburden consisting of sand, gravel, silt and clay. (b) Rock foundations—rock starting from ground level or where it is economically feasible to remove over-burden. The depth of exploratory investigation should ordinarily reach bed rock, or else, through all soft, unstable and permeable strata of the overburden. For purposes of preliminary estimates, Angas and Proctor (Ref. 5) suggest the depths of exploration of one-half the bottom width for earth fill dams and levees not exceeding 100 feet in height. For concrete dams not exceeding this height a depth of twice the height from stream bed to crest is suggested. For large or unusual dams no such limits of depths can be recommended.

The scope of general exploration is restricted to the determination of the depth, thickness, extent, and composition of each soil stratum, depth of rock and depth of ground water, and also to obtain *approximate* data on the strength and compressibility of the strata. General exploration is to be carried by geophysical methods, sounding and penetration tests, open excavations, exploratory boring (usually 2½ inch dia.) and rock drilling. Geophysical methods and subsurface soundings are considered convenient means of determining depth and general topography of bed-rock. Representative samples of the over-burden should be obtained from borings (auger and wash boring) and open excavations and tested as given in Table 1 below.

TABLE 1

Tests Recommended for General Exploration

	Type of soil	*Tests Recommended*
1.	All types	Colour, smell, gradation (sieve analysis).
2.	Coarse grained	Grain shape.
3.	Fine grained	Liquid limit, plastic limit, moisture content, unconfined compressive strength.

In-situ sounding and penetration tests will expose the general character of the over-burden and indicate the critical spots and strata requiring detailed exploration and further testing.

Rock Foundation: One of the first requirements in exploring a site for a dam is to determine whether a suitable foundation is available for the spillway and outlet structures (Ref. 6). The spillway and outlet are almost always masonry structures in water-sheds of any size and are built on rock whenever possible. For dam construction, there is no better foundation than that of sound rock (Ref. 2) free from structural weaknesses like faults, crushed zones, cavities and layers of compressible and washable interbedded material. The rock should be free from volume changes due to variation in moisture content and should not soften or disintegrate when subjected to saturation and pressure of a long duration. It should also be chemically inert with the stored water and be strong enough to support the structure without crushing or undue settlements.

When rock is used as a foundation, it must sometimes be examined in greater detail than is necessary in a soil formation. The following features require investigation (Ref. 6): Depth of weathering, location of fault zones if any, extent of joining or of bedding planes, existence of solution, cavities large or small, the presence of intervals of soluble material which may produce future cavities and the possibility of rock disintegration upon exposure to the air as do certain shales (this has bearing on the requirements for paving in rock cuts and on the use of excavated rock in the fill or as pitching or ballast). In jointed or fractured zones the presence and nature of material such as clay in the seams may be important especially at the time of reservoir filling, when hydrostatic pressures may develop to a significant extent.

The above information is obtained by core drilling (Ref. 2) in rock, which provides samples for observation and for petrographic and physical analysis. The holes are also used for observation of ground water condition and performing other field tests required in detailed exploration of the final phase of investigations. Use of portable diamond drilling equipment is found satisfactory for the conduct of preliminary investigations. Holes can be drilled on an inclination if desired to check the sequence of steeply dipping strata or to more advantageously explore a particular structure. The number, location and depths of core-drill holes during any stage of the investigations depends on local conditions and the information to be obtained. Obviously it has to be decided by the geologist. Under certain conditions, it may be better to locate the holes with reference to dips and strikes or other structural features than to place them in straight rows in order that the resulting logs may record an uninterrupted sequence of formations. Within the damsite area, holes are located along the line of the dam axis and cut-off trench or trenches and at intermediate points in the river bed and abutment areas. These holes are usually drilled vertically. Inclined holes may be drilled from the abutments for transverse exploration below the riverbed to insure the cutting of burried channels or non-conformities that may lie between the vertical holes and that would otherwise remain undiscovered, or to expeditiously check the succession of formations.

The preparation of a topographic preliminary geological map (Ref. 2) is necessary to assist in making the final choice out of the several prospective sites. This map should show all surface outcrops and covered areas with proper classification of the overburden. In regions of igneous and metamorphic rocks, outcrops should be classified according to the kind of rock and the contacts between different types mapped. In sedimentary rocks, a geologic column should be prepared. Structural features like faults shear zones and major joint system should be shown wherever possible.

Exploration for Construction Material

After the compeletion of general exploration of probable foundation sites, preliminary designs and estimates can be prepared if exploration is extended to the construction materials which mainly consist of the following: Cement, natural aggregates, stone (for masonry, crushed aggregates, rock-fill, riprap, filters, soling and road metal, etc.), earth materials for earth dams, bricks and wood. This paper deals only with the investigation and selection of earth construction material used in rolled fill construction.

Before undertaking exploration of borrow areas it is necessary to determine with considerable accuracy the characteristics and quantity of the material (both soil and rock) which may be required to be excavated for founding the dam. When once the quantity and nature of probable excavations are known, the quantity and type of borrow materials required for the embankment dam can be estimated. Investigations are needed to determine the quality (suitability), quantity, location and mode of exploitation of available borrow materials. A wide variety of materials are suitable for embankment construction as illustrated in Fig. 1 which is given by U.S. Bureau of Reclamation (Ref. 2). Unsuitable soils are those which contain soluble or organic matter.

It is desirable to locate the most suitable source of materials which are nearest and most accessible. A hauling distance of less than one mile is desirable, but it may have to be exceeded in many cases. The deposits to be explored should contain at least one and a half times the yardage of the finished embankment. Exploration is usually carried by hand augers and test pits dug by hand picks and shovels. In some cases, the use of draglines, power augers, bull dozers, or drilling equipment may be desirable. Geophysical methods have also been used for material deposit exploration. The test holes for exploration should penetrate a depth (Ref. 2) of 20 or 25 feet of suitable materials, or to bed rock or the gruund water level, whichever occurs first. The approximate depth of shovel cut is 20 feet, therefore, if multiple cuts are to be developed, the test holes should be proportionately deeper. If an appreciable amount of stripping is anticipated, the depth of test hole must be proportionately greater.

Undisturbed but complete and representative samples should be obtained, fully classified by the field examination tests (Ref. 3) and sent to the laboratory for further testing. Mechanical analysis and index properties tests will suffice for preliminary investigations. Determination of stone content (over 5 or 6 inch size) is important in borrow areas, because it cannot be easily placed and compacted in embankment. It may be necessary to completely remove or break the oversize material before placement. Stone content has a marked influence on compaction.

Results of general exploration should be submitted in the form of a report (Ref. 2) giving the following information :

1. Map location of each material's source. The location at which samples were taken should be indicated for each source.
2. A description consisting of a few narrative sentences on the topography, materials, ground water, and other pertinent information.
3. A description of the vegetal covering the source.
4. The thickness of the deposit as estimated from exposures and test holes.
5. The estimated aerial extent of the deposit.

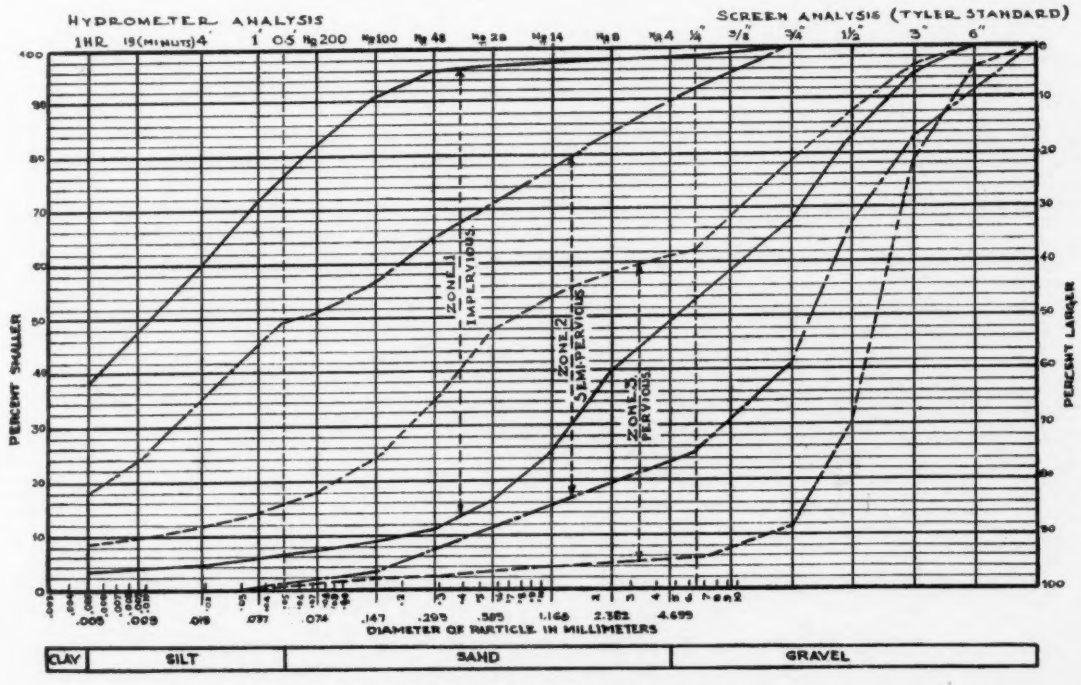

Fig. 1. Range of Particle Size Distribution in Earth Dams

6. An estimate of the percentage of oversize materials.
7. Description of the overburden as to type, thickness prevalence of roots. etc.
8. Logs for all test holes.
9. Results of field tests and laboratory tests if any.
10. The ownership and accessibility of the source.

Final Investigations

The final investigations will generally comprise the following studies : (a) Topographical: preparation of accurate large-scale maps for the sites of all important structures, (b) Hydrological : the most complete and detailed extension possible of the preliminary hydrological studies, and (c) Detailed sub-surface exploration of the foundations and construction materials, including rigorous sampling, insitu laboratory testing.

Detailed Foundation Exploration

The three main stability problems of a dam foundation are bearing capacity, compressibility and seepage. Methods of obtaining information about bearing capacity and compressibility of cohesive and non-cohesive soils have been described by the author elsewhere (Ref. 4). This information is obtained by securing undisturbed samples and testing them in the laboratory and supplementing the results with in-situ tests. Samples are to be obtained from open excavations and borings. Because of the general request for larger test samples heavy exploration equipment of greater capacity is being developed. Very often test pits are excavated to obtain large size hand cut undisturbed samples and for in-situ examination and testing. Rodin (Ref. 7) reports the use of power-auger borings of 8 to 36-inch diameter, and upto 30 or 40 feet. used mainly in unconsolidated soils above the ground-water table. The larger holes are used to allow a man to make an accurate inspection and to sample the soil in place. At both the U.S. Bureau of Reclamation and Corps. of Engineers the large diameter samples, 4-inch to 6-inch diameter, appear to be more widely used for final design investigations although at the Waterways Experiment Station the 3-inch diameter thinwall tube samples are now considered generally adequate (Ref. 7).

Permeability Determination :

Reliable information on the permeability of soil (especially cohesionless soils) is essential both for solving cut-off and seepage problems and for estimating the inward flow of an excavation with specified diamensions, at a given position of the water table. Information about permeability is obtained by tests on samples or by field tests. In order to solve the cut-off and seepage problems it is necessary to determine not only the average permeability of the sub-soil but also the major variations of the permeability within the strata located beneath and beside the water-retaining structure (Ref. 8). This can be done only by means of permeability tests on fairly continuous series of samples obtained from a considerable number of drill holes. Best results are obtained from tests on undisturbed samples, but because of the difficulty of obtaining undisturbed samples of cohesionless soils, results may have to be based on testing of representative samples. Samples are obtained from 4-inch to 6-inch drill holes by means of a sampling spoon equipped with a core catcher (Ref. 8). Tests should be performed at the remoulded sampled density and also at various other remoulded densities including the limiting maximum and minimum densities. After making 15 or 20 permeability tests on samples from a given stratum, a trained laboratory technician may be able to estimate the co-efficient of permeability of the samples of the stratum on the basis of their texture and general appearance. Because of the technical difficulties with sampling in cohesionless soils, it is almost inevitable that some parts of the strata may not yield any samples at all. The gaps in the cores may be the source of important errors in the evaluation of the permeability of the stratum.

Field permeability tests are very often used on dam projects to furnish data for a study of seepage problems. There are numerous methods for carrying out field permeability tests. The most common of these methods (pumping water into or out of wells) have been summarised by Rodin (Ref. 7).

It is often considered desirable to determine the relative magnitude of the permeability coefficients in vertical and horizontal directions. A significant difference in vertical and horizontal permeability very often exists in the alluvial deposits which form the valley floor at most dam sites. As a rule this can be measured only by tests on undisturbed samples. The pumping tests furnish information only about the average horizontal permeability. An estimate of the average vertical permeability can be based on the results of tests on undisturbed samples in which water flows at right angles to the bedding plane. However, the calculation of the average permeability will be based on the tacit assumption that the permeability of the stratum is the same at every point on any plane parallel to the bedding planes. This assumption is very seldom justified (Ref. 8). Moreover, the cores are never perfectly continuous. The occurrence of a single seam of silt located between two adjoining samples of sand elimmates the validity of the computation of average vertical permeability. Terzaghi and Peck (Ref. 8) refer to a method of estimating the ratio of the average horizontal and vertical permeabilities which is based on construction of flow nets. Under normal circumstances this method is very expensive and cumbersome.

Rock Foundation Exploration :

Compared to preliminary investigation, larger diameter core drilling equipment is generally used

for final exploration of dam sites. A greater number of drill holes may be necessary to cover the site fully. The cores of different kinds of rock should be sent to the laboratory for the determination of strength and modulus of elasticity, specific gravity, and petrographic examination. When the geology and magnitude of the job demand, a most reliable and detailed inspection of the strata in-situ is made by excavating tunnels and drifts or drilling large-size bore-holes.

A number of field tests (Ref. 2) are required for rock foundations. Firstly it is necessary to check the verticality or determine the drift of drill holes, because otherwise serious errors may be made in interpretation of results of drilling, especially in steeply inclined strata where the drill has a tendency to follow the bedding. The three methods used are : the hydro-flouric acid method, the gelatin method, and the photographic method. The seams and cavities in the foundation strata for small areas can be studied by lowering a periscope into the bore holes. Special collapsable instruments for determining the location and extent of the cavities have also been developed. Percolation tests are used for determining the permeability of the strata or the probable leakage through joints or fissures in the rock and to estimate grouting requirements. Single packer or double-packer system is used. Single packer system is used as the hole is being drilled and the double packer can be done after the hole is finished. A section of the hole is blocked off by a rubber packer assembly and water is pumped in under a head approximating that of the proposed reservoir, if possible.

After the investigations, a final geological map and comprehensive report should be prepared for the selected site and the adjoining areas.

Detailed Investigation of Earth Construction Materials :

Based on preliminary investigation those deposits which are in close proximity to the project site and are considered as the most promising sources of earth materials, are further investigated in detail. The investigations should be able to define the quantity and quality of earth construction materials within fairly narrow limits. The areas to be explored should be covered by a number of test holes, pits or trenches. There is no rigid rule defining the spacing of test holes or pits. It depends upon the variability or uniformity of the materials. It is generally desirable to space the test holes 400 feet apart, but in deposits known to contain uniform materials, the spacing may be as much as 1000 feet (Ref. 2). The best procedure is to start with a wide spacing for the test holes and to add others in between as the variability of the deposit may require. All the test holes and pits should be located in parallel lines on a grid system so that subsurface profiles may be plotted and quantities calculated.

During explorations it is desirable to record the difficulty of excavation, as it will affect the cost of the operations. The *in-situ* density of the material should also be determined in order to calculate shrinkage or swell from borrow pit to embankment. Representative samples from test holes and pits should be collected for classification, compaction, remoulded shear and permeability tests. Determination of the natural moisture content and its seasonal variation is also essential. With gravelly soils having appreciable amounts of material larger than $1\frac{1}{2}$ inches, it may be necessary to screen representative samples in the field to determine the proportions of minus $1\frac{1}{2}$ inches, $1\frac{1}{2}$ to 3 inches, 3 to 5 inches, and plus 5 inches. For a reliable estimate of stone content it may be necessary to analyse a sample weighing as much as several tons (Ref. 6). When all detailed exploration and testing are over, a comprehensive report on materials covering the various points as indicated in the general exploration report should be prepared.

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FABRIDAM

(*Continued from page* 23)

This Westinghouse dam is one of five completed installations fabricated by Firestone's Coated Fabrics Division at Los Angeles, California. Two are located in the Los Angeles River, one serving as a canal gate and the other as a main diversion dam.

Others are located on the spillway of the Austrian Reservoir of the San Jose, California Water Works and on the spillway of the Wahiawa Reservoir in Honolulu, Hawaii. Numerous other installations are under consideration throughout the United States and the rest of the world.

S. R. S. Mani

Flood Control: an approach

WITH the intensive cultivation and afforestation in the country there is going to be more and more rain, which, in turn, means more and more floods. This year's floods have shown to what extent they can cause devastation. If we cannot do something to prevent or atleast check these floods, then life will become very difficult for people living in towns and villages close to rivers. When we see hundreds of square miles of land inundated with 10 ft. of water and villages washed away, one feels that it is impossible to prevent floods and that there is no other way but to accept it as an unavoidable evil. Of course, rivers can be prevented from flooding if all the water that inundates the hundreds of square miles of land can be impounded in storage tanks, thus checking them from flowing into the rivers. Is it possible to build such large storage lakes to hold so much water? Even if these are constructed, it is possible that the river may become flooded before reaching the storage tank and burst its banks. If this happens, the storage tank is bypassed and becomes useless. Further, these tanks can prevent or check the ferocity of the floods once. When the river gets flooded a second time due to heavy rains in the catchment area and all along its course, nothing can be done to minimise the ferocity of the water since we have already filled the storage tanks only a few days ago to prevent an expected flood.

All these thoughts make one feel utterly helpless in the matter. But all these fears are, to a great extent, due to the wrong assessment of the conditions that cause floods. If flood water is capable of inundating miles of land and washing away hundreds of villages, then there is nothing we can do to prevent it. But, fortunately, flood water is not capable of causing so much havoc. By flood water is meant the excess water that overflows the banks. This water is not more than a few inches and this little quantity of water cannot cause so much damage if it merely overflows the banks and enters the surrounding fields. But, unfortunately, what it actually does is that it rips open the banks, thus diverting the entire river straight into the villages and cultivated fields. So it is the several feet of river water that is the cause for all the damage and not the few inches of overflow water. Hence if we can prevent this small quantity of excess water from reaching the main river, then the river can be prevented from breaking its banks and flooding the fields even as saving the entire dyke by blocking the small hole in it. When once we realise it is this small quantity of overflow water which is the cause for all the trouble, even as a spark is the cause for the burning of the entire petrol tank, the task of attempting to control floods will look much simpler. Here I give the scheme which, in my opinion, can easily tackle the problem.

Flood Control Tanks

We all know the main river depends for most of its water supply on its tributaries. The tributary, in turn, depends upon the innumerable hill streams or nullahs which carry the rain water and empty into it. It is a fact that almost all tributaries of the main river, especially in the South, are dry for the major portion of the year and have water only during the monsoon. These are all just rain water rivers. So, let us tackle the problem from the root, i.e. the streams that supply rain water to the tributary. Since these streams are very small ones, one storage tank per stream, similar to the irrigation tanks that are commonly seen in almost all villages, will be quite sufficient to hold its water. The size of the tank will depend upon the quantity of water carried by the stream. It is not necessary that this tank should be capable of holding all the water that the stream will bring throughout the monsoon. For the purpose of this scheme, it is enough if it is capable of holding seven days' flow of the stream. If this quantity should be found too much for a single tank, two or more tanks can be constructed in series.

So, with the construction of these flood control tanks, it becomes possible to prevent the rain water from hills reaching the tributary for seven days. This means the tributary will not receive water for seven days from the streams and hence its level will fall considerably.

Small Dams

Of course, by cutting off water supply for seven days from the streams, we cannot make the tributory dry for seven days, because it being a long river, will be collecting rain water all along its course. So, even after cutting off the supply from the streams, the tributary can have large quantity of water to empty into the main river. Hence it is necessary to reduce the quantity of water reaching the main river by constructing a dam for holding a good quantity of water. Of course, since the tributary has only a reduced quantity of water

after the F.C. tanks have been commissioned, the dam can be a small one capable of holding about seven days' supply. If one dam is found too small, then two or more dams can be constructed at strategic places.

So, with the construction of these dams it becomes possible to control the flow of water into the main river. The F.C. tanks stop their supply to the tributary and the tributary, in turn, stops its supply to the main river for a period of seven days.

Bigger Dams

Since the length of the main river is several hundred miles, the cutting of water supply from the tributaries will not make the river go dry as it gets enormous quantity of water at its source and also collects rain water all along its long journey. If there is heavy rain in the catchment area and all along its way, still there is the possibility of the level of the river rising and overflowing its banks. Of course, the chances are less, but we must provide for everything. One or two dams of fairly big size (but certainly not so big or so pucca as the big irrigation dams like Hirakud or Mettur) should be constructed at strategic points. These dams also should be capable of holding about seven days' supply.

So, with the construction of the F.C. tanks and miniature dams it becomes possible to control the flow of water in the main river for seven days.

Here I must explain why I am stipulating seven days' water supply. We all know the peak period of floods does not last for more than a day or two. So, immediately the level of the main river reaches the danger point, instructions can be issued for collecting the water in the F.C. tanks and dams. As the water collected in seven days will be much more than the water the main river may get due to any unforeseen rains, it is safe to impound so much water.

Operation of F.C. tanks and Dams

The whole success of the scheme entirely depends upon the method of operation. It is quite different from the operation of the irrigation tanks and dams, which are meant to store water and supply for irrigation as well as for power production. These F.C. tanks and dams are not expected to supply water for irrigation or power, but meant to hold water just to prevent the main river getting it.

To achieve the desired result, these F.C. tanks and dams should be *empty* before the monsoon and should continue to be so even during the monsoon. Even the rain water collected in the tanks and dams should be allowed to flow off. When the main river assumes flood conditions and touches the danger point, then only these tanks and dams should be brought into use to prevent the excess water reaching the main river.

There is one point we must always bear in mind. Of course by filling the F.C. tanks and dams the river can be prevented from flooding once. What happens if the river gets a second round of heavy rains in the catchment area and all along its course? Since the F.C. tanks and dams are already full this time, nothing can be done to prevent the river from overflowing. It is, therefore, very necessary that we should not be placed in any such unhappy situation. This is how these F.C. tanks and dams should be operated:—

When the river rises up to the danger level, water supply should be cut off by filling the F.C. tanks and dams. This will have an immediate effect on the river and the level will fall by atleast 3 to 4 feet. Immediately this happens, again the water from the F.C. tanks and dams should be released and allowed to flow into the river. This may raise the water level, but it will not do any harm as long as we see that the danger level is not crossed. This will keep the F.C. tanks and dams again empty, ready to meet the second bout of floods in case it comes even a few days after the first one.

Controlled flooding

In the case of some peculiar rivers, as are found in the north, all the above steps may be found inadequate to prevent the river from breaking its banks under some very extraordinary conditions. Since we are preparing a project for making it impossible for the rivers to cause floods, we must provide for every eventuality. In this case, instead of the river breaking its banks at its pleasure and flooding the land, we break the banks and allow the river to flood an area pre-determined by us. This controlled flooding will cause the minimum damage, as the area selected by us will be less fertile with no villages nearby. For allowing the water to pass through the banks the principle adopted for letting water from the irrigation tanks can be followed, i.e. by constructing concrete or stone anicuts. These controlled outlets can also be built at strategic points a few miles ahead of big cities and towns which are known to be vulnerable to floods, to save them from horrors of flood.

The above steps, in my opinion, are an effective answer to the turbulent rivers.

Cost

The cost involved for executing the above project should not be beyond the means of the State Governments. The F.C. tank at the streams will only have earthern bunds similar to the irrigation tanks in villages. Since these tanks are required to be constructed at the foot of the hills, stones and mud required will be available at site. So, the cost of each tank, say 200 yds. x 200 yds., will not be more than Rs. 1 lakh.

The small dams for the tributory and also for the main river should not also cost much since they are not required to be as strong or as pucca

as the irrigation dams. Another advantage is these tanks and dams do not need the services of foreign experts. The exact cost can be worked out by the local P.W.D. authorities.

Uses

We all know floods are not an annual feature, but occur once in four or five years and extraordinary floods such as the present one occur after several years of interval. So, these F.C. tanks and dams will remain idle for years together. Even during the year when there is the fear of floods, they will be used only for a month or so. To keep so many thousands of acres of land covered by these tanks idle will be a great national loss. On the top of that, to keep these tanks in proper repairs a good lot of money will have to be spent annually, which is an unproductive recurring expense. So, something should be done to see that these tanks earn at least their maintenance expenses. The following steps are suggested :—

(i) If the soil is good, cultivation can be done and the crop rotation should be arranged in such a way that the tanks are free and available during the monsoon for flood control purposes.

(ii) If the soil is not very good, then trees can be planted in these tanks. This will fetch income as firewood and timber. Another advantage is that this will go to strengthen the tanks and dams.

(iii) Though these tanks and dams are not meant for irrigation, they can be used for irrigation in an indirect way. We all know most of the rivers, especially in the South, are just rain water rivers and become dry just after the monsoon and remain so till the next monsoon. These rivers can be made to carry water long after the monsoon by manipulating these F.C. tanks. It can be done this way. Immediately the peak period of the monsoon is over and we are sure that there will not be very heavy rains capable of swelling the river to dangerous levels, these F.C. tanks and dams can be filled up and when the rivulets become dry, water from these tanks and dams can be released and allowed to flow into them. As these rivers will have water long after the monsoon is over, it will help irrigation over a much wider area than even the irrigation dams which cater for the needs of only the surrounding area. This will help the cultivators to grow more on account of the availability of water for a longer period after the monsoon. This is a very great advantage.

So, by putting these tanks and dams to the above uses, they can be made to earn atleast their maintenance expenses and will not be a total liability on the National Exchequer.

Conclusion

In conclusion, since the scheme provides for everything, it is very elaborate and I do not think there are many rivers in India which will need so much of precaution to be taken. The rivers can be classified into three categories—(i) Very dangerous, (2) Dangerous, (3) Less dangerous :—

Very Dangerous : Rivers that carry huge quantity of water, quickly reach the danger levels and remain there for a long time, slowly recede, break their banks in several places all long their route.

Excepting one or two in the North, I do not think there are such rivers in the South.

Dangerous : Take time to reach the danger level, remain there only for a short time and recede quickly, lose their ferocity immediately after breaking the banks in one or two places.

Such are the rivers common in the country and require strong steps to be taken.

Less dangerous : Rivers that swell due mainly to extraordinary heavy rainfall within a very short period. These can be controlled by costruction of one or two F.C. tanks and do not require elaborate treatment.

I. D. A. LOAN FOR THREE IRRIGATION AND DRAINAGE SCHEMES

A four-member delegation, headed by Shri M. R. Sachdev, Secretary, Union Ministry of Irrigation and Power, is in the U.S.A., for negotiating loan assistance from the International Development Association for the Shetrunji and the Salandi irrigation projects in Gujarat and Orissa, and drainage schemes in Punjab.

The Shetrunji irrigation project envisages construction of a dam across the river Shetrunji in Gujarat State, to provide irrigation facilities to an area of 86,000 acres. A provision of Rs. 7.3 crores has been suggested for this scheme in the Third Plan.

On completion, the project will yield about 27,000 tons of foodgrains and cash crops every year. The construction of the dam will also help towards flood control in the area.

The Salandi project envisages construction of an earthen dam across the Salandi river in Orissa State, and has been included in the Third Five Year Plan to provide benefits to an area of 327,000 acres and to yield about 40,000 tons of foodgrains and cash crops every year. A provision of Rs. 3.46 crores has been suggested for this project for the Third Plan.

The drainage project of Punjab has been taken up to improve surface as well as sub-surface drainage in an area of about 39 lakh acres, which was heavily inundated during 1958 floods due to drainage congestion.

The total cost of the schemes is estimated at Rs. 68.81 crores and it will take a long time to complete.

K. B. Khanna
Larsen & Toubro Ltd.

Maintenance pays dividends

YEARS OF ENGINEERING EXPERIENCE AND RESEARCH in maintenance have proved that every machine, small or big, requires maintenance. While design engineers are constantly trying to reduce the maintenance points on machines, they have not yet been able to do away with maintenance altogether. Even on automatic mchines one has to carry out regular maintenance. In fact, on such machines maitenance becomes even more important. It become evident that the more automatic the design of a machine, the important becomes its maintenance.

Surprisingly enough, few people realise the importance of maintenance and periodic checks. How much money do they waste every year by neglecting the maintenance of their machines ! Neglect of maintenance of a machine, which is built up of the finest material available, would lead to the service life of the machine being considerably curtailed. Materials of the best quality and highly skilled manufacturing methods go into the construction of a tractor, shovel, crane, fork lift or dredger. These machines are important for the fast handling of large quantities of materials and a great deal of attention must be paid to their proper maintenace.

Maintenance of a tractor, shovel, crane or fork lift should be planned and carried out under the following four heads :

1. Good operation
2. Frequent Inspection and Adjustments
3. Prompt repair when necessary
4. Last, but not the least, regular lubrication

It must be remembered that "*Lubricants are always cheaper than spare parts*".

It will be agreed that major repairs are very often due to belated attention to the machine and improper lubrication or not adhering to the lubrication schedule recommended by the manufacturer.

Taking into consideration a crawler tractor, which is extensively used these days by contractors for earthmoving and construction work, it is imperative for a contractor to analyse his expenses to find how savings could be effected, more so, when the earthmoving bids have become more and more competitive. One major point where saving can be effected is in his maintenance bills. An intensive productive maintenance schedule will prevent the small problem from growing into a major repair and resulting in loss of production for several days.

It is amazing, but nonetheless true, that a few minutes spent each day on every machine will allow the maintenance crew to solve the problems before they get out of hand. An hour off the job at the start of trouble can mean additional productive days for the machine.

The author demonstrating the correct *Air Gaps* on Electro-Mechanical Brakes and their importance to the Bombay Port Trust chargemen and electricians.

The author (fourth from left) stressing the importance of the correct adjustment of tracks of Caterpillar Tracttors in a talk to the members of the Institution of Engineers when they visited the Powai Works of Larsen & Toubro Limited.

Take, for instance, the case of recoil springs and tracks of a track-type Caterpillar Tractor. Just imagine a common thing as mud and dirt packed tightly into the exposed recoil springs. If this is not cleaned, then the idler travel and recoil action becomes limited and restricted. These impediments overstress on recoil mechanism, on the track link assemblies and, to a considerable extent, on the final drive as well. The net result of this is that the rate of wear increases and repairs are needed sooner.

Most of the trouble on tracks are always due to improper track adjustment. In a crawler tractor which is engaged in earthwork, especially in a rocky area, extra attention to the tracks is very important. The correct adjustment on tracks must be ensured, since the machine will soon require expensive repairs if the tracks are too loose or too tight. It takes only a few minutes to adjust the tracks and the correct adjustment as a rule is 1″ to 1½″ of sag. Machine fitted with hydraulic adjusters take still lesser time, as these adjusters require only a small amount of extra lubricant to tighten the tracks or the removal of some lubricant by turning off the valve.

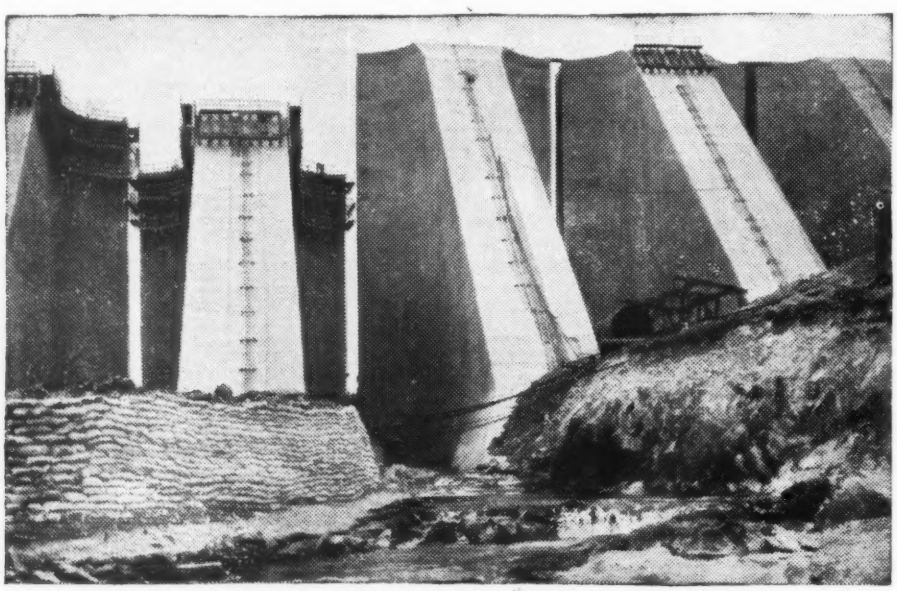
Loose tracks can create a lot of trouble and make the repair bill fat. For one thing, loose tracks cannot maintain alignment and will lead to wear on the sides of the rollers and idler flanges; for another, undesired wear takes place on the sides of the links and bushings. Loose tracks have a tendency to *whip* at high speeds and when the tractor turns, this puts an unduly heavy load on the carrier rollers and support brackets.

This does not mean that over-tight tracks are better; they can also do severe damage to the machine. Hundreds of tips could be given on the maintenance and adjustment of tracks alone, which is beyond the scope of this article. However, it is necessary to note that an experienced operator is a great asset and intelligent supervision by the maintenance crew will overcome many difficulties.

It would certainly not be economical to have a big, highly paid maintenance crew to service a few machines. If that be the case, the services of the dealer who has a number of first-rate engineers, many of them factory-trained, must be utilised. The dealer will be too pleased to depute his engineer at a nominal charge, which is certainly worth spending as the machine would be inspected by a trained hand and a keen eye.

Before concluding, it must be added that the importance of following the manufacturer's recommendations on the proper maintenance of each machine cannot be over-emphasised. Do not hesitate to consult a representative of the manufacturer regarding any maintenance points that may not be covered in the instruction manual or of which you may be doubtful. The use of wrong lubricants may be termed as sabotaging a machine; so never use a wrong lubricant. Moreover, should any component fail prematurely and if you claim a free replacement from the suppliers, the claim may not be entertained if the suppliers, after the investigation, find out that the failure was due to the usage of wrong lubricant or improper adjustment.

In a nutshell, preventive maintenance and the use of the correct grade of lubricant are imperative for trouble-free operation of any machine.



New Dam for Hydro-Electric Scheme in Wales
A new dam takes shape on the River Rheidol at Nant-y-Moch in Cardiganshire, Wales.

Fabridam

A COLLAPSIBLE RUBBER DAM FABRICATED BY THE Firestone Tire & Rubber Company controls the flow of water used to generate power at one of Pennsylvania's largest factories.

The installation—called a Fabridam—is in operation at the East Pittsburgh, Pennsylvania, factory of the Westinghouse Electric Corporation. It controls the water level at intakes to condensers, where water is pressurized for the turbines which generate part of the power consumed in the huge plant.

The Fabridam, a giant nylon bag coated with neoprene synthetic rubber and inflated with 40,000 gallons of water, replaces a conventional concrete dam on Turtle Creek, a tributary of the Monongahela River.

The primary advantage of the rubber dam, compared with its predecesor, is that it can be deflated to permit unobstructed runoff and increase the carrying capacity of the stream.

The Fabridam was designed by Norman M. Imbertson, engineer in charge of the Water Plant Operating Division for the Los Angeles Department of Water and Power, to reduce flood hazards and replenish underground basins.

Westinghouse is well aware of the importance of flood control after two floods in the last 25 years caused millions of dollars worth of damage to the factory. In case of a flood, the rubber dam can be collapsed in a maximum of two hours, permitting a sharp increase in the normal 35,000 or 40,000 gallon-per-minute rate of flow into the nearby Monongahela, which joins with the Allegheny River at Pittsburgh to form the Ohio River. This is usually enough time, because flood warnings from points upstream are received approximately four hours in advance.

However, the dam collapses automatically much quicker if the headwaters build up rapidly. When a storm causes the creek level to rise, the excess water flows over the top of the dam. The weight of the water flowing over the dam increases the pressure on the water inside the dam. When this pressure reaches a predetermined stage, the water in the dam is discharged through a gate valve and the dam starts to deflate.

When completely deflated, the dam lies flat on the bottom of the creek channel, and all debris is carried over it by the water. Fully inflated, the dam maintains the water level at eight feet at the intake to the condensers, which require 20,000 gallons of water per minute.

The Fabridam in action

The Fabridam normally is inflated in about five hours from a pipe connection through the channel wall. However, this can be done in 15 or 20 minutes if necessary by using a larger hose.

The 6,300-pound dam, shaped like a tear drop, is stretched across the creek bottom and anchored to the bottom at the upstream edge with stainless steel bolts set into a concrete slab on the floor of the creek. It is 95 feet long with each end bolted to a concrete embankment on each side of the creek.

The designer recognized that the dam would have to be constructed of some material that would withstand the abrasion of water-borne rocks and sand, and would collapse so flat that roots, floating trees and general trash would pass over it easily.

Rubber and synthetic rubber are such materials. Since they are flexible, they can be made to collapse, they withstand abrasion well (a truck tyre is an example), they can be reinforced with fabric to give them strength against tearing, and they are not excessively expensive. Since natural rubber tends to weather and check in sunlight, neoprene, a synthetic rubber that weathers well, was selected for the dam. It was reinformed with nylon fabric for maximum strength.

(*Continued on page* 17)

P. Ethirajulu

A New Hydro-electric Scheme on River Bhavani : A Proposal

INDIA IS MOVING IN LONG STRIDES TOWARDS industrialisation of the country and modernisation of rural life which requires cheap and reliable source of power. At this juncture Hydro Electric Power compete and at times outweigh the other types of resources of power. The great Kundah Hydro Electric Scheme itself is sufficient to speak the truth.

River Bhavani and its important tributaries the Kundah and Pykara-Moyar, rise amidst peaks of Nilgiri hills in Western ghats at altitudes of over 8000 feet. Situated at the top of Nilgiri ranges, their catchments receive heavy rain fall and the course of the river is characterised by sharp drops, which can be utilised for power generation. Bhavani takes its shape at the start of its run by the confluence of upper Bhavani and Bhavani puzha at an altitude of about 6000 feet, and flows for certain distance in a generally southwards direction in steep and narrow valley till about R.L. 1750 feet. From there, as it is a east flowing river, takes a turn towards east and continues its onward journey on an easy slope and occasional drops. Rivers Varahapalam, Kundah and Kiralapallam from north, Siruvani and Karingapallam from south and some streams join River Bhavani before it is met by river Coonoor. Kunda Hydro Electric Scheme is very characteristic, in that small catchments which are subjected to heavy rainfall are drained, the waters collected and in some cases diverted into main Avalanche-Emerald storage reservoir for regulation. The very high head (5333 feet) available is utilised in different stages and thus every effort is made to use all available waters and head for the generation of enormous power (343,000 kW). The upper reaches of Bhavani with a catchment area of 12.96 sq. miles and minimum rain-fall of over 100 inches is drained into upper Bhavani Reservoir by construcing a dam at a bed level 7260 feet and the waters are diverted into Avalanche and Emerald Reservoir to be made use of in all the four houses of the Kundah Hydro Electric Scheme. In the III stage of the same scheme, one of the proposals is, to construct a dam (Pillur dam) across the Bhavani below the infall of Niralapallam. This picks up the tail race water of power house No. 3 as well as free flow from 322 sq. miles catchment of Bhavani river itself and a power house situated at the dam itself utilise the water with a head of about 210 feet for power generation.

Proposed Scheme

In this article a new scheme is proposed to utilise the waters of a part of river Bhavani flowing through Kerala State to generate electric power.

In the course of its run from Upper Bhavani dam to the proposed Pillur dam site the river Bhavani travels through Kerala State for a part of its journey and enters again into Madras State at about R.L. 1500 feet. In this part of its run the river drains a catchment area of about 220 sq. miles situated in Kerala State with an average rainfall of about 80". To the south of the place Mukkalivangai (at this place a stream Pantham Todu joins river Bhavani) where Bhavani turns towards east from its southward journey, rise some streams to form a small west flowing river Ambanwadavu Todu which is a confluent of Thuthapuzha. The river Thutha Puzha later joins the river Ponnari which is a west flowing river. It is found that there is an enormous drop in ground level within a few miles from the bed of Bhavani at the turn (Mukkalivangai R.L. 1750 feet) towards the Southwest direction (bed of the river Ambanwadavu Todu R.L. 250 feet). In this scheme it is proposed to utilise this drop, by diverting a part of east flowing waters of river Bhavani into the west flowing river Ambandadavu Todu, for power generation. A sincere and serious consideration should be given to the problems arising out of this diversion of east flowing water into the west flowing river.

At present the entire free catchment of Bhavani (322 sq. miles) from upper Bhavani dam to the proposed Pillur dam is drained into the reservoir at the Pillur dam and the waters are regulated to the possible extent to generate hydro electric power at a gross head of about 210 feet. The tail race waters trace the normal course of Bhavani and join river Cauveri, the waters of which are effectively utilised primarily for irrigation and also for further power generation. According to the scheme proposed in this article, out of the waters of 322 sq. miles of free catchment, a part (waters of 75 sq. miles) is to be diverted into west flowing Ambankadavu Todu, if the head available should be used for power generation.

A dam constructed on Bhavani at the bed level

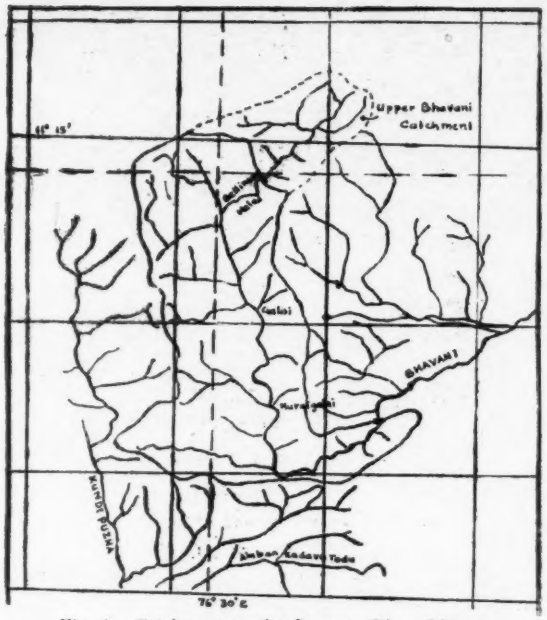


Fig. 1. Catchment at the Dam on River Bhavani

of about 1690 feet near Seramankandi drain a catchment area of about 75.0 sq. miles making provision for upper Bhavani pumping scheme also. (Fig. 1). It is expected that the waters will back upto a point beyond the bend of Bhavani. Water conductor system from the take-off from the river bed near Mukkalivangai to the Powerhouse consists, as shown in Fig. 2, cutting for a part of the distance, a channel, a tunnel across the ridge of Varakandi Malai, and penstocks for a certain distance. For some length alternative proposal of cutting or tunneling is shown in the drawing. From R.L. 300 to R.L. 250 there is not much of slope in ground. Hence to effect saving in the length of penstocks, it is proposed to cut the ground at R.L. 300 to a depth of 50 feet and locate the power-house in that at an R.L. 250 The tail-race waters are lead in to the bed of Ambankadavu Todu at R.L. 250 through a channel.

Hydrology

An average run-off of 125 m. cft. per sq. mile for the catchment of Bhavani lying in Kerala State can be taken for arriving at the power draft. This and the following information is given in "Water Resources of Kerala—A Compendium of advance Report" published by the Kerala State P.W.D. (Irrigation Branch).

Bhavani River

Average rainfall	80 inches.
Catchment area in Kerala State	220 sq. miles.
Estimated Run-off	27000 M. Cft.

Hence total estimated run-off from the area of 75 sq. miles is about 9200 M. Cft. Allowing for evaporation losses of 700 M. Cft. water available for power generation is 8500 m. cft. which gives a power draft of 270 cusecs. Since Bhavani, like other Indian rivers is characterised by wide variations in stream flow between the years of good rainfall and lean years, it is the amount of regulation that is feasible economically, that determines the continuous power draft. It is found from topo-sheets that the storage available at the dam is not poor and facilities are available for good and effective regulation of entire waters for continuous power output. It can be seen from the following data, found from Survey of India maps, that storage to an extent of 700 m. cft. can be provided economically.

Bed level at the dam site is 1690 feet.

F.R.L.	*Water spread*	*Capacity of*
	Area Sq. miles	*Reservoir* M. cft.
1690	0	0
1700	0.42	294
1750	1.39	1300
1800	2.42	4000
1850	3.10	7870

Allowing for dead storage due to silt the minimum draw down can be taken as 1730 feet. F.R.L. of 1850 feet is sufficient to give a net storage capacity of 7000 m. cft. This gives the dam height to be 160 feet plus a free board of about ten feet. Two small bunds are to be provided for the reservoir on the southern side as shown in the Fig. 2. The tail-race R.L. of 250 feet gives a gross head of 1530 feet. The average firm power then comes to be 46,000 kW at 60% load factor.

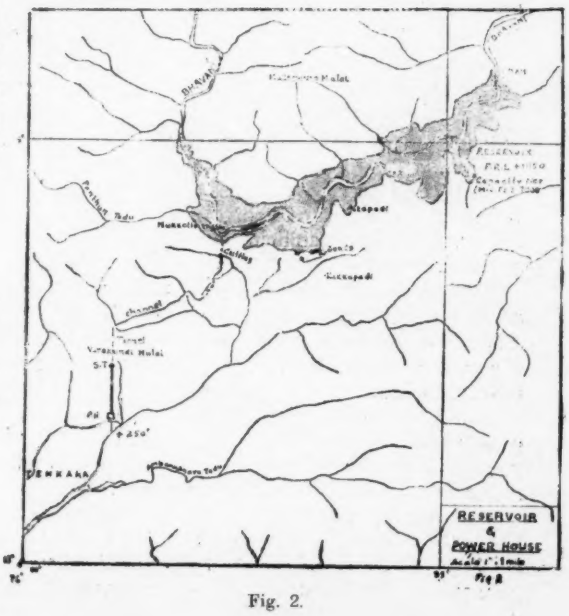


Fig. 2.

Conclusion

The power output of the Kundah Hydro-Electric Scheme may not be affected much by the implementation of this new scheme and this scheme gives more power output. As is usual in the case of east flowing rivers, the power developments on river Bhavani, might be restricted only by the irrigation requirements of the lands wetted by Cauvery waters. However, the scheme utilised the drop for economic generation of large power and the benefits shall be weighed against the agricultural advantages.

Site investigation and detailed study of available hydrological data will expose ultimately the technical difficulties, benefits and economy of the scheme.

Summary of the Proposed Scheme

Dam on river Bhavani :

Location	76°-36′ E ; 11°-6′ N.
Height	160 plus 10 feet free-board
Length at R.L.	1700 ft. is 400 ft.
at R.L.	1850 ft. is 1000 ft.

Bunds : (i) 300 feet length height 40 feet
(ii) 900 feet length height 70 feet

Catchment area :
75.0 sq. miles Run-off 9200 m. cft.

Water conductor system :

Cutting 2800 feet	Channel 9600 feet
Tunnel 3000 feet	Tailrace 1150 feet
Surge tank located at	76°-31′ E ; 11°-2′ N.
Poper House located at	76°-31′ E ; 11°-1.5′ N.

Reservoir :

F.R.L. 1850 feet	Min. Draw down level 1730 feet
Gross Capacity	7870 m. cft.
Live storage	7000 m. cft.

Average Power Draft 270 cusecs.
Gross head 1530 feet.
Average continuous Power Output :
46,000 kW at 60% L.F.

WATER DEVELOPMENT IN JAPAN

(*Continued from page* 28)

and vegetables which are produced on dry land. This problem, together with that concerning technology for the utilization of water, are being studied more closely.

Another problem worth studying together with ways to utilize water is that of converting paddy fields into dry fields for growing crops other than rice for a year or two and then converting them back into paddy fields. By this method the fertility and productivity of the paddy fields can be increased and also reduce water requirements. At any rate, the modernization of water utility by farmers who are the biggest water consumers will, it is believed, contribute to lessening the shortage witnessed among other water services.

MAJOR ELECTRICAL DEVELOPMENT IN BRITISH GUIANA

Civil engineering work has been started by a British consortium as part of a £ 2½ million project to expand and rehabilitate the electricity supply system in Georgetown, capital of British Guiana.

The consortium, the AEI (British Guiana) Partnership, has been formed by the Export Company of Associated Electrical Industries Ltd., International Combustion (Export) Ltd., and Taylor Woodrow (Overseas) Ltd.

Taylor Woodrow (Overseas) Ytd. are now engaged in constructing the foundations of a new power station, which, because of the swampy nature of the ground, will be supported on piles.

The power station will initially house two 10,000 kilowatt steam turbine generators, with provision for a future third set. The first of the 10,000 kilowatt generators is expected to be commissioned at the end of 1962.

The two 10,000 kilowatt machines, which will generate at 11 kilovolts, and associated equipment, are to be supplied by Associated Electrical Industries, their boilers by International Combustion Ltd. In addition, the existing electrical distribution system will require renewal and reinforcement in the process of a gradual changeover from the present distribution voltage of 4 kilovolts to 11 kilovolts. This work will be carried out by AEI engineers.

The current civil engineering work is the beginning of the second stage of what has been virtually a crash programme to relieve the shortage of electrical power in Georgetown. The whole project can be viewed as a prelude to greater developments in Guiana, where future power requirements may be met through hydro-electric generation.

Water Development in Japan

JAPAN LACKS NATURAL RESOURCES, BUT WATER IS an exception. Rainfall in the country averaged about 1,670 millimeters a year and, in terms of volume amounts to approximately 600,000 million tons.

Most Japanese rivers are swift and short and enter the sea only too soon. This is one factor which makes water resources somewhat unstable. Another reason is the time difference in preicpitation. Yet she is much better off than other highly developed countries as far as rainfall is concerned ; the average annual precipitation in the United States is 750 millimetres, in Italy 500 millimetres and in Britain 630 millimetres.

Because of abundant rainfall, agriculture in Japan has developed since early prehistoric years, and with the advent of the industrial revolution in the modern age, the demand for water for indutrial purposes has risen sharply. Particularly with the development of the heavy and chemical industries in recent years, the demand for industrial water has increased considerably.

Water for Agriculture

Paddy field agriculture in Japan developed mainly on alluvial soil surrounding rivers and during the Tokugawa Era, the basis for the present irrigation system was completed.

Traditional water rights run counter to all modern economic principles. But this situation which is characteristic of Japan is due to historic practices observed in establishing the water rights system. It is said that the volume of water enough to irrigate 3,350,000 "chobu" (one cho equals about one hectare) of paddy field is from 30,000 million tons to 60,000 million tons. There are many places in the country where paddy fields have been expanded to the maximum, causing a shortage of water supply during the drought seasons when river water is at the lowest level.

On the other hand, there are places in the country where new demand for agricultural water has arisen because of land improvement and reclamation projects carried out in order to raise productivity, and also along with the recent policy of the Government to increase production on dry land.

Water for Power Generation

Hydroelectric power, which has been produced cheaply and abundantly because of the rich water resources in the country, has played a big role in the development of the nation's industries. Although the volume of water used for power generation does not diminish, the way it is utilized by power companies greatly affect other uses of water.

On the other hand, thermal power generation has been stepped up sharply in recent years because of the construction of giant thermo-electric plants as well as the progress in its technology.

A shift has been witnessed in the two types of power generation. Hitherto, the main emphasis had been placed on thermoelectric power output. However, the importance of hydroelectric power generation has increased because of the power load at peak time. As a result, a number of large-scale reservoir-type dams are being constructed. This tendency will greatly affect the use of water in the future because of the vital relations it has with the time of generation and release of the water from the dams.

Industrial Water and City Water

During the 1930's it was comparatively easy to obtain industrial water either from rivers or underground sources, but, a great change has taken place after the war. The phenomenal growth of the national economy has resulted in an acute shortage of water for industrial purposes.

Industrial development of modern Japan has been centered on the chemical textile, synthetic chemical, fertilizer, iron and steel and metal industries which consume a large volume of water. It is natural for these industries to build their plants and factories where conditions for production are most favourable, and a large number of plants and factories are concentrated in certain localities where water is better met. As a result, a great shortage of water is being witnessed today at such sites.

Expansion of industries inevitably induces concentration of the populace, as well as expansion of cities and increase in consumption. This in turn creates a bigger demand not only for industrial water but also for city water and water for refrigerating and cooling purposes. According to statistics compiled by the Ministry of International Trade and Industry in 1958, the volume of water used for industrial purposes that year was 26,000,000 tons of sea water and 24,000,000 tons of fresh water.

In regard to consumption of fresh water, the supply from surface water sources decreased, while the supply from underground water, public water service and recovered water increased, indicating the acute shortage of industrial water.

The value of water, when it can be freely obtained, is the same as that of air, but the more the shortage of water is felt, the more valuable it becomes, and it can be said that it will finally decide the fate of industries. Strong demand creates strong rights which are inviolate. When such a situation comes to pass, the dependency on underground water increases because of its favourable quality and temperature. This in turn results in the lowering of the level of underground water because of overpumping and finally leads to the sinking of the ground. The problem lies not only in the sinking of the ground itself but also an acute shortage of water in that locality, and makes it imperative to enforce appropriate countermeasures.

Future Problems

Development and growth of a certain district are fundamentally related with the problem of whether adequate water is available or not. Since the supply of water is not limitless, the problem lies in how to distribute it appropriately among industries as well as among the city water services.

According to the Government's double-the-income programme, production by mining and manufacturing industries is expected to increase three-fold in 10 years. It is only natural that the demand for water 10 years hence will increase at the same rate.

The problem of water supply has cropped up only recently so that sufficient data have not been gathered and the price of water is not clearly defined. However, in comparing the expenditures for the use of agricultural, industrial and city water and that for hydroelectric power generation, the percentage of the former is found rising. If water presently poses a bottleneck to the growth of the nation's industries, it is said that more emphasis should be placed on public investments in this field in order to reinforce the foundation of the industries. It is also considered necessary to formulate a long-range perspective of demand and make investments which will cover a long period in the future.

Since the investments will amount to an enormous sum, a special organization is urged to be established for the investments themselves and the way they are to be managed because there are many cases in which the consumers who are to foot the bill are not definitely known at the time construction projects are started.

(1) *Multipurpose Dams*

River water is utilized in various forms—for generation of electricity, for irrigation purposes, for drinking water and for industrial purposes. But at the same time, river water causes considerable flood damages in Japan.

If it is possible to carry out the work of utilizing the water and controlling it simultaneously, it would be more inexpensive than building separate dams to hold water for each purpose. Although there are contradictory points between the utilization of water and its control as well as among the methods of utilization, it is believed that the construction of large-scale multipurpose dams and their efficient management would no doubt solve many of the water problems.

(2) *Raceway Facilities*

More efforts must be made to improve raceway facilities for industrial as well as drinking water in parallel with the construction of multipurpose dams. The improvement of these facilities will tend, in many cases, to eliminate losses and make distribution and consumption easier and smoother.

Under the present situation where raceway facilities are not adequate and a shortage of water supply is being witnessed, there would be many cases in which such a situation will be improved by constructing new facilities. For example, under existing conditions, it is necessary to keep a certain volume of water always flowing in the river in order to obtain needed water and prevent it from being polluted by sea water.

However, if new facilities are constructed, all these will either be eliminated or at least diminished.

Of course, difficult financial problems will be involved, but because of the importance of obtaining an adequate supply of water at present, more efforts are urged to be made in this direction.

(3) *Early Rice Cultivation.*

Is there any other method to increase the utilization rate of water now being used and create some surplus? The original objective of the early cultivation of rice is not the utilization of water, but the prevention of the shriveling of the stalks in autumn, the rotation of farm crops as well as to avoid typhoon damages as much as possible. However, the early cultivation of rice changes the time when water is utilized.

The period when rice cultivated in paddy fields needs the largest volume of water is in the month of August when the water in the rivers is at the lowest level. The cultivation of early rice makes it possible to avoid the period when the water shortage is most acute and consequently, the water economized be used for other purposes during the dry season.

Aside from the favourable effects early cultivation of rice will have on the production of other farm products, there is a new significance in this method of cultivation. As the rice seedlings have to be replanted before the rainy season sets in, so-called rice bed water must be secured in adequate quantity. Despite many difficult problems to be solved, more studies and efforts are made for this type of early rice cultivation.

Because the dietary habits of the Japanese people are expected to change in the future, it is believed that more demand will rise for dairy products, fruits

(*Continued on page 26*)

The Audit of Performance

THE Third Five Year Plan is now before the country, not for discussion any more, but for implementation. That a developing country should plan in order to promote rapid and coordinated exploitation of resources—on this there is hardly any major division of opinion in the country. Already two Five-Year Plans have been executed and the third has been discussed and debated for quite a long time. Even now criticisms appear regarding, not the Plan as a whole, but its implementation. The Prime Minister therefore was very right when he said that "the real problem before India (now) is one of implementation and not one of laying down policies."

In the course of the last decade the State apparatus has grown tremendously. It is no longer a mere law-and-order State. It is a State that not only plans, encourages and initiates development ; it undertakes direct responsibility for executing a very large number of major and minor projects of various kinds spread out all over the country. On top of this it has expanded its supervisory, inspection and control functions, as the country's development expands. In sum, the State as an organ of public authority has recently grown and become more complex and interwoven, and there seems to be no end to this process in sight. All this has taken place in only a decade. Could we imagine it in 1950?

The implementation of such a major Plan as the third one admittedly is, can therefore, be accomplished only if the meaning of this task is clearly visualised. The Prime Minister put the matter very succinctly indeed. He said: "In enforcing this *audit of performance* it becomes necessary that responsibility should be given to the person who has got to do the job. It is still too greatly concentrated. It is better to take risks and face losses and not have this centralisation". Elaborating the same idea, Mr. Appleby, the renowned specialist on administration, says: "India is in fact in a state of emergency such as obtains when a nation is at war. Its success in this emergency depends upon *rapid decision-making and rapid action*". He advocated "the need to educate responsible top organs of Government in the ordinances of self-denial which would *restrict their intervention to really important concerns*".

In the sphere of Community Development this idea of decentralisation was given shape now for some time. At first there was great expectation from the C.D.P. Now the Prime Minister's observation in this respect provides a certain balance and perspective that are crucially relevant even in other spheres. He says: "I think it (CDP) did a great deal of good but I must confess that after a while it seemed to lose its shine and get into a rut, like everything else. Unless one is constantly awake, things get into a rut; things get officialised; things get tied up with bureaucracy." "Oddly enough, the very enthusiasm of the officials in charge of it produced a good effect on the one hand and a bad effect on the other, because they tried to do everything themselves and the community waited for them to do it. This is not our objective. We want the community to do it." Then came the stress on two or three things, leading to what is called by 'democratic decentralisation'. It is almost a test. Although we have always talked about Panchayati Raj, it had no particular meaning. But the content of it now is to throw the burden on the Panchayats, to give them resources, to give them authority, and to tell them to go to God or to the Devil, as they choose. It is always essential in such matters to have the liberty to go to the Devil, because if you do not give that liberty, the fellow does not go to God either. He does not do anything. Therefore, it is essential to give them power and authority, even taking the risk that they will misuse it. Only that way can they learn."

But an ever-expanding bureaucracy with proliferating State organs has its own logic. The Prime Minister has proved an extremely sensitive person, being himself involved in the machine, in diagnosing the disease of bureaucratism and the concomitant cynicism and complacency that is pervading fast in the C.D. apparatus. But the same thing is true in other spheres as well—of course with brilliant exceptions. If implementation of the Third Plan has to be undertaken with some vigour, not merely official but real, then the Government, both at the Centre and the State, must consider in concrete and specific terms how to pass on the responsibility (as well as powers of decision-making) down the ladder quickly. If this can be experimented with villagers, it should be more confidently tried with educated executives and engineers. Unless this is done on an effective scale throughout the country, one can confidently predict that the Govt. will get more and more enmeshed in its own web of bureaucracy, rules and power-hierarchy from which it will be difficult to disentangle at a later stage.

Our Contributors

Mr. V. P. Appadurai is Chief Engineer, Electricity, Madras and has been a frequent contributor to cur journal.

Mr. S. K. Nargundkar was educated at Deccan College, Poona. Joined the Indian School of Mines Dhanbad in the year 1928. Obtained First Class Diploma of A.I.S.M. Went to United Kingdom in 1932 for four years' study and practical training. Obtained 1st Class Certificate of Competency (Great Britain). After working for about a year in a private consulting firm, joined Tatas Coal Department in 1936 and was Dy. Superintendent of Collieries with headquarters at Jamadoba. Joined the Singareni Collieries in July 1949 as Dy. General Manager and assumed charge as General Manager in April 1954.

He was a Director of the National Coal Development Corporation Limited for two periods 1959/60. In addition, worked as a member on various Committees set up by the Central as well as State Governments.

Mr. Alam Singh is Reader in Civil (Soils) Engineering College, Jodhpur. He had contributed together with Prof. R. M. Advani, an interesting article on Flow Net in August 1958 issue of our Journal.

Mr. S. R. S. Mani graduated in Coimbatore College, Coimbatore. Joined Bombay Development Department in 1924. Subsequently joined the Engineering Department of Messrs. Volkart Brothers, Bombay. After working in the various sections, became Secretary to the All India Departmental Head of the Agricultural and Construction Equipment Department. Later became Secretary of the Planning and Development Department till retirement.

Mr. K. B. Khanna graduated in Engineering in 1952. Worked for short periods with Bombay Electrical Supply Transport and Undertaking, Bombay and at Bhakra Nangal Dam, Nangal. For further knowledge and experience, left for U.K. in January 1954. Specialized in Materials and Mechanical Handling, while working with a leading crane manufacturer. During the stay in U.K. attended a short course in Market Research at Kings College, New Castle, Associate Member of the Institute of Materials and Mechanical Handling, London. Joined Larsen and Toubro Ltd., as a Sales Engineer in 1956. Now a Senior Sales Engineer and in charge of sale of materials handling and allied equipment.

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Mr. P. Ethirajulu passed B.E. Electrical Degree Examination of Sri Venkateswara University in 1959. He took up postgraduate studies in Power Engineering (Elec.) at the Indian Institute of Science, Bangalore. Completing the academic part of the course in December 1960, he received practical training at the Central Water and Power Commission. In the Commission he is acquainted with different aspects of Power System designs and problems connected with it. He has joined the Regional Engineering College, Warangal (A.P.) as Associate Lecturer in Electrical Engineering.

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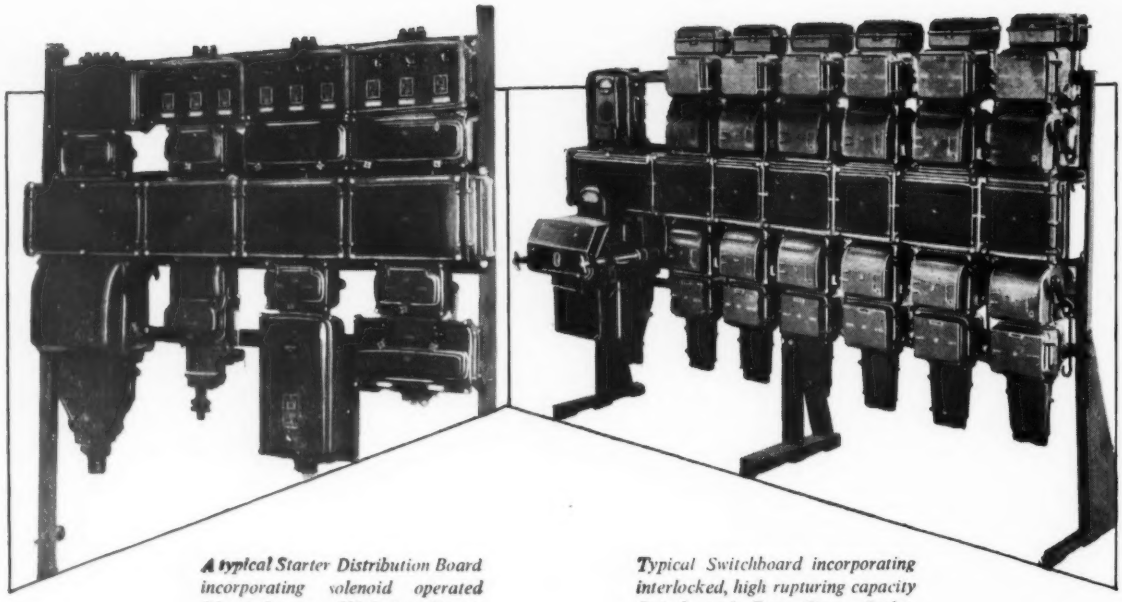

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